U. S. DEPARTMENT OF AGRICULTURE.

THIRD REPORT

OF THE

UNITED STATES

ENTOMOLOGICAL COMMISSION,

RELATING TO

THE ROCKY MOUNTAIN LOCUST, THE WESTERN CRICKET, THE ARMY WORM, CANKER WORMS, AND THE HESSIAN FLY:

TOGETHER WITH

DESCRIPTIONS OF LARVÆ OF INJURIOUS FOREST INSECTS, STUDIES ON THE EMBRYOLOGICAL DEVELOPMENT OF THE LOCUST AND OF OTHER INSECTS, AND ON THE SYSTEMATIC POSITION OF THE ORTHOPTERA IN RELATION TO OTHER ORDERS OF INSECTS;

WITH

MAPS AND ILLUSTRATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1883.

JOINT RESOLUTION AUTHORIZING THE PRINTING OF THIRTY THOUSAND COPIES OF THE THIRD REPORT OF THE UNITED STATES ENTOMOLOGICAL COMMISSION.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed at the Government Printing Office, with necessary illustrations, thirty thousand copies of the Third Report of the United States Entomological Commission; seven thousand copies thereof for the use of the Senate, twenty thousand nine hundred and seven for the use of the House, and two thousand and ninety-three for the Interior Department.

Approved, February 26, 1881.

EXTRACT FROM LAW PROVIDING FOR THE COMPLETION OF THE WORK OF THE UNITED STATES ENTOMOLOGICAL COMMISSION UNDER THE DEPARTMENT OF AGRICULTURE.

Investigating the History of Insects Injurious to Agriculture, 1882. * * * *Provided,* That to enable the Entomological Commission to complete and publish the data already obtained by them, with the investigations made, the sum of five thousand dollars of said sum of twenty thousand dollars is hereby appropriated, to be expended under the direction of said Commission; and the reports of the said Commission, and an itemized statement of their expenditures, shall be made to the Commissioner of Agriculture.

Act of March 3, 1881.

TABLE OF CONTENTS.

CHAPTER V.

PART II.—THE ARMY WORM, CANKER-WORMS, AND THE HESSIAN FLY.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

PART III.—SCIENTIFIC RESULTS.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

APPENDICES.

APPENDIX I.

APPENDIX II.

APPENDIX VIII.

APPENDIX IX.

LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., July 31, 1882.

SIR: On behalf of the United States Entomological Commission and in accordance with the act of Congress, approved March 3, 1881, which provides that the reports of said Commission be made to the Commissioner of Agriculture, I have the honor to submit this, its third report, which was in preparation and was ordered by Congress while the Commission was yet under the Interior Department.

Respectfully,

C. V. RILEY,
Chief U. S. E. C.

Hon. GEO. B. LORING,
Commissioner of Agriculture.

MEMBERS OF THE COMMISSION.

C. V. RILEY, *Chief.*

A. S. PACKARD, JR., *Secretary.*

CYRUS THOMAS, *Disbursing Agent.*

PREFACE.

This report was planned during the period when the Commission was charged by Congress with the investigation, not only of the Rocky Mountain locust, but of other insects injurious to agriculture. Hence it is divided into three parts.

Part I embraces chapters on the Rocky Mountain locust and on other locusts and the Western cricket. In Chapter I some additional chronological facts for the years 1880 and 1881 are given; while Chapters II and III contain reports of observations in the northwest territories for the years 1880 and 1881 respectively, by Mr. Lawrence Bruner. It has been the object of the Commission, since the completion of the work on which our first and second reports were based, to have the breeding grounds of the locust examined annually, as far as possible, with a view of ascertaining the prospects of injury or immunity from its ravages the ensuing year. Mr. Bruner's work was in pursuance of this object, and the results were given to the public at the time, pending the delayed printing of this volume.

In Chapter IV Mr. Bruner has also given a list of the species of locusts known in North America, and some notes on the Western cricket.

Chapter V contains some interesting data, by Mr. A. H. Swinton, on the probable connection of locust multiplication and migration with solar phenomena.

Part II embraces three chapters, and is devoted to popular treatises on three well-known injurious insects of national importance.

Chapter VI, by Mr. Riley, treats of the Army worm. It has been prepared with a view of presenting a full and connected statement of all that is known in reference to the insect, and will be found to contain, in addition, a number of recent facts and observations not elsewhere recorded.

Chapter VII, by Mr. Riley, treats of Canker worms. It is also a general account of these destructive insects, prepared with a view of bringing together the more recent discoveries with regard to them.

Chapter VIII, by Mr. Packard, treats in a similar manner of the Hessian fly, and is, in fact, a revised edition of Bulletin No. 5 on that insect.

Part III is devoted to miscellaneous subjects, and contains the more technical matter of the report. It embraces four chapters relating to the development, metamorphoses, and anatomy of the locust and other insects, the result of more purely scientific studies carried on with the more practical work of the commission.

Chapter IX, by Mr. Packard, contains a number of descriptions of the larvæ of injurious forest insects, and is accompanied by numerous figures by Dr. Carl F. Gissler.

In Chapter X, by Mr. Packard, there is given a partial account of the mode of development of the locusts (*Caloptenus atlanis* and *spretus*), prefaced by a general, but brief, account of the embryology of insects in general; a few concluding pages are devoted to some points in the breeding habits and development of two bark-boring beetles destructive to evergreen trees. This chapter also contains a discussion as to the mode of origin of the wings of insects, with a final section on the number of segments in the head of winged insects.

In Chapter XI, also by Mr. Packard, are given the results of extended studies on the external anatomy of insects of the order Orthoptera, (to which the locust belongs), together with that of the allied orders. This has led the author to propose a separation of those Neuroptera with complete transformations (as had already been done by certain German and English entomologists), from the Pseudoneuroptera, and to regard these two groups, with the Orthoptera and Dermatoptera (earwigs), as four orders of a category which may be regarded as a super-order, for which the name *Phyloptera* is proposed. The characters of the Phyloptera are given, and those of the four above-mentioned orders, followed by some suggestions as to their probable genealogy; closing with a condensed statement of the essential peculiarities of structure of the families as represented by one or more typical genera, and illustrated by numerous figures.

The twelfth and concluding chapter comprises a brief description of a colored zoological map of North America, supplementary to accounts of the geographical distribution of the Rocky Mountain locust given in the first and second reports of the Commission.

The appendices include (I) early references to the occurrence of the Hessian fly in North America; (II) extended articles on the Hessian fly, translated from the German of Dr. Herman Löw and Dr. Balthasar Wagner; (III) an account of injury to grain in 1869 by the Hessian fly in Silesia, from the German of Dr. Ferd. Cohn; (IV) a translation of an account of the same insect, by F. T. Köppen; and (V) Dr. H. A. Hagen's discussion as to the original source of the Hessian fly.

Appendices VI and VII contain brief reports, by Mr. John Marten and by Mr. A. J. Chipman, of observations on the Rocky Mountain locust in 1880; Appendix VIII gives a number of notes on locusts, and especially of their injuries and the means used against them in other countries; while Appendix IX contains some interesting experience on the Spring Canker-worm, by Mr. Martin A. Howell, jr.

The Commissioners heartily thank the various correspondents who have replied to inquiries, and take pleasure in acknowledging their indebtedness to Mr. A. H. Swinton, of England; Rev. Samuel Lockwood, of Freehold, N. J., and Mr. Martin A. Howell, of Greenwood, Ill., for contributions; to Mr. L. O. Howard, and Mr. B. P. Mann, of the Entomological Division, for material assistance in the preparation of Chapters VI and VII respectively, and to Dr. Carl F. Gissler, for drawings.

CHAPTER I.

ADDITIONS TO THE CHRONOLOGY OF LOCUST RAVAGES.

THE ROCKY MOUNTAIN LOCUST IN 1880 AND 1881.

This chapter is in continuation of a similar one in our second report. The reader is referred to a succeeding chapter for data regarding the locust in Montana and adjoining regions, and also for Nebraska, where special observations were made by our assistants in the field. As will be seen, the locust committed only local ravages, and these in rare cases, this year. The distribution of the scattered, thin swarms was pretty much as in 1879.

THE LOCUST IN TEXAS IN 1880.

While no locusts were reported in this State in 1878 (see our second report, p. 2), swarms of locusts were reported May 17, 1879, at Dallas. In the autumn of 1880 large swarms flew into the region of Jacksboro, as will be seen by the following extract from the daily papers:

> In Jacksboro, Tex., yesterday, immense swarms of grasshoppers appeared, coming from the north, at times obscuring the sun. A farm near here is completely demolished, even the cotton stalks being devoured.

Mr. Henry Boll, of Dallas, corroborated to us this statement, stating that at a point 17 miles northwest of Jacksboro they flew into Lost Valley late in September, and that the ground was literally covered with them. He also saw them quite numerously in China Creek, Wichita County, near Wagner's ranch, in October. A few were also seen in the air passing over Dallas, October 20–25, 1880. They hatch out early in April at Dallas, "when the plover are here to feed on them." The swarms usually arrive early in October, and are apt to injure the new winter wheat.

During our trip to Texas, in the spring of 1881, we obtained the following additional information. At a region thirty or forty miles west of Corsicana the locusts flew in from the north, in October, 1880, and laid eggs, but none had hatched April 3, the date of our visit. We were told that the locusts had visited Corsicana itself twice only within eighteen years, and then they came too late to do any harm, the young in the spring appearing in scattered swarms.

Into Tarrant County locusts flew the last of September, 1880, but in small numbers.

At Eastland, the last appearance of locusts was in the autumn of

1879, when they flew in from the north all along the line of the Texas and Pacific Railroad, the northwest winds bringing them in from the "plains," which extend eastward to within about 150 miles of Eastland.

In Indian Territory no locusts appeared in 1880. Three years ago locusts flew in at Eufaula.

THE LOCUST IN COLORADO IN 1880.

The locust was locally a little more injurious in Colorado this year than in 1879, but, as will be seen by the following letter from the editor of the Colorado Farmer, none appeared in the State until late in summer:

DENVER, COLO., *September* 24, 1880.

DEAR SIR: In reply would say that locusts appeared in our parks about the 1st of August, bred there, I think, and a few swarms, very local in extent, reached the vicinity of Boulder and Longmont and Denver about the 12th of August. In a few places they were quite thick and slightly injured a few acres of grain and garden vegetables. They have not attempted to get far from the "foot-hills," and have been working in an unsettled and distracted kind of a way. Some have coupled, and some bored into the ground, as if to lay eggs; but I have hunted somewhat in their holes for eggs and only found one bunch, and others whom I have requested to hunt report finding no eggs.

I do not have any apprehension of locusts next season, or at least in numbers to hurt, but I would not be surprised if they reached here in 1882 in numbers sufficient to do damage.

Yours truly,

J. S. STANGER

Prof. A. S. PACKARD, Jr.,
Providence, R. I.

P. S.—The locusts apparently came from Middle and North Park, and it was reported some came over the range from the northwest.

J. S. S.

THE LOCUST IN UTAH IN 1880.

During our journey to Utah, late in July of this year, no locusts were seen or heard of in passing over the Union Pacific Railroad through Wyoming. None were seen or had been seen by residents this year at Laramie, Rock Creek Station, or in Echo Cañon, in Utah. On the 26th they were seen in abundance at Lake Point, Salt Lake, but no damage was done by them. Some were heard of below Provo, and inquiries elicited the information given below. A few appeared in Cache Valley. The following correspondence shows the distribution of locusts in this Territory this year, while Map I will indicate the direction of flights:

From May 19 to the beginning of June, grasshoppers were pretty generally present throughout Central Utah, but not in great abundance, except in some places near the dry benches, where the hatching went on, and young wingless 'hoppers visited the cultivated patches, &c. But as a general thing our people know more of the habits of these pests and take effective steps to get rid of them.

The routing them out by digging up and burning eggs appears to be the most simple method, as I stated to you.

Memoranda for Dr. Packard.

May 21, 1880.—Beaver and surrounding places, "abundant."
May 31.—Young hoppers numerous on northeast of Salt Lake City.
June 11.—Plenty at Springville.
June 12.—Provo Valley.
June 16.—Cache Valley. Benches.
July 26.—Grasshoppers were reported.
Also early in July, abundant on the farm land.

MUSEUM, SALT LAKE CITY, UTAH, *July* 31, 1880.

MY DEAR SIR: I received your postal card. Was extremely sorry to learn that you had been attacked with chills and fevers, the very maladies which commenced my late serious illness. I do hope to hear of your speedy recovery. The note I prepared for you I inclose. I have, since I saw you, heard from Provo and from Juab County (from Mona) that about three weeks ago the 'hoppers developed suddenly and have done much mischief in places. I forgot to mention to you that I have told many of our people to write to you directly from their own homes, and I have found that some have done so, respecting insect pests generally.

Should it be your wish, I can get you complete statistics at any time by putting a request (to our leading men in our settlements for information) in our church papers.

I am quite satisfied that the migratory 'hoppers secure favorable places in our side cañons, and even in well-traveled cañons, where the ground is favorable for depositing eggs. I have seen places where usually foliage abounds quite desolated by the overwhelming horde of young 'hoppers, which develop in myriads at times. In one side cañon (Brigham's Fork), in Emigration Cañon, I saw a very curious sight in 1873. The young 'hoppers were there in great strength. They had eaten everything green, except the foliage of trees growing by the side of the creek, which had withered up by reason of the tent caterpillars having taken up a position on the upper branches, presenting the appearance of a vast sheet, so completely had everything been covered. Not many of these 'hoppers came down into the valley, but a few weeks after the Weber Valley had a visit. Nothing was done to destroy these creatures; in fact, only "wood-hawkers" ever visit such out-of-the-way places. I was up there looking after a suitable building stone for parts of our temple, or probably the singular sight I allude to would have escaped observation. Some men with me, who work in the mountains regularly, told me such sights are very common in the "forks" of Red Butte, Porley's, and other cañons of the Wasatch.

How the tent caterpillars got on subsequently I had no means of learning. On the principle of "the survival of the fittest," I think the "'hoppers" could escape the best to other feeding places.

I remain, dear sir, yours, respectfully,

JOSEPH L. BARFOOT,
Curator of the Salt Lake Museum.

Dr. A. S. PACKARD, Jr.,
Entomological Commissioner, &c.

SALT LAKE CITY, UTAH, *August* 6, 1880.

DEAR SIR: In accordance with agreement, I take pleasure in giving you such information touching the grasshopper as I have been able to pick up in a trip to Frisco, the end of the Utah Southern Railroad. Some six weeks since the grasshopper appeared in San Pete Valley, doing a little damage. A few have been seen about Provo, Nephi, and contiguous regions. At present quite a swarm is devastating the district about Mona Station, traversing a strip 1 mile wide by 5 long. I saw the insects flying southward to-day in that region. Their chief damage has been to oats.

The war locust is being seen this season in small numbers on the mountains about Frisco.

Very respectfully,

E. E. WOOD,
Assistant Editor Chicago Evening Journal.

Prof. A. S. PACKARD, Jr.

GRINNELL, POWESHIEK COUNTY, IOWA,
October 4, 1880.

MY DEAR SIR: A short time ago I received a letter, which had been delayed, from a friend in Kanosh, Millard County, Utah. He reports as follows:

"1st. The grasshoppers have laid their eggs in this locality for two years, about the middle of August.

"2d. They have done most damage to barley and wheat.

"3d. The young seem to travel east.

"4th. The young receive their wings about the middle of June.

"5th. The old ones remain and lay their eggs here. They are depositing eggs now, August 29.

"6th. Various plans have been tried to destroy them, but failed. We think the best is to plow and harrow the land, and if any young hatch out, take all available chickens to pick them. In this way a great many have been destroyed already, but they are so numerous that many portions of the fields have been completely stripped."

This letter was written August 29. Before leaving Salt Lake I met with a friend who had seen the 'hoppers at Kanosh, and from his description of them I think that they are of the same species as those I sent you. He also stated that he met a man in Kanosh who had lost 10 acres of grain.

Very respectfully,

OR. HOWARD.

THE ROCKY MOUNTAIN LOCUST IN 1881.

All our information this year concerning flights and solitary appearances of locusts in the Rocky Mountain region is embodied in the following chapter, by Mr. L. Bruner, containing a report of his observations for 1881. The two maps for 1880 and 1881 will give the main facts in graphic form.

THE LOCUST IN TEXAS IN 1881.

We could not learn that any locusts were hatching out in the State, except at one point, as at the time we passed through Texas, April 1–7, the season had been remarkably cold and backward, and it was early for them to appear. At Eastland, however, we saw a man who had come the day before from Abilene, on the Texas and Pacific Railroad, who informed us that the locusts were hatching out at a locality 10 to 20 miles west of Eastland, and that in one place he observed them thick upon the ground. This would indicate that a scattering swarm laid their eggs near Eastland last autumn.

While, therefore, no damage was done in Texas in 1880 and 1881, the locust is indigenous to the plains lying in the northwestern part of the State, and from this region every year light scattering swarms are carried eastward and southward into the inhabited lower portions of the State. But it is only in exceptional and very infrequent seasons that the locust will ever swarm into the State in destructive numbers.

The facts we learned and the knowledge of the State we obtained,

added to our experiences in Colorado and New Mexico, have taught us that the locusts which formerly afflicted this State must have been derived from the plains in the western part of the State, and from the valleys of the Arkansas and Canadian Rivers, *i. e.*, from western and southern Kansas and southeastern Colorado, as well as western Texas and Indian Territory.

On Map II we have inserted the flights and breeding grounds of 1881, with some additional flights reported by Mr. Bruner in Chapter III.

THE LOCUST IN UTAH IN 1881.

As we have observed in a former report, every year since 1851, in Utah, with two exceptions, and those perhaps are such from deficient data, there have been at least a few locusts existing in swarms. That some hatched out about Salt Lake City will be observed from the following letter from Mr. Joseph L. Barfoot, curator of the Deseret Museum, and the extract from the Salt Lake Herald appended:

SALT LAKE CITY, UTAH, *May* 12, 1881.

DEAR SIR: I received yours of May 2, respecting the larvæ of Clisiocampa, which I will get for you and send in alcohol. I have put up also in spirit a few specimens of the young 'hoppers, which I noticed in the Herald, of which I send you a cutting, with date. I publish these things, as they reach our people, who seldom see the longer papers. The young 'hoppers were observed by me for a long time. They struggled for life nobly, pushing the earth away, and, when I offered food to them, taking a rest for a moment to refresh themselves, and then commencing again most vigorously to free themselves. Then they would emerge with a leap of 2 or 3 inches, would again rest, as though much exhausted, eat again, and very rapidly become quite capable of taking care of themselves. Dr. Heber John Richards found the creatures "in a perfectly torpid condition," to use his own words, and "in less than three minutes, when they were in loose earth, and exposed to the influence of the sun, they became lively." I have no doubt that millions of these creatures have been destroyed by our people in harrowing the soil after the eggs had been deposited, as well as by the ordinary agricultural operations.

One of our people has made a simple machine for crushing the grasshoppers. If a photograph can be taken, I will send you one.

As soon as I get the supplies of larvæ, I will mail to you.

With great respect, I remain, yours, truly,

JOSEPH L. BARFOOT,
Curator.

Dr. A. S. PACKARD, Jr.,
Entomological Commission.

GRASSHOPPERS.—Dr. H. J. Richards, of this city, on Thursday, exhibited specimens of young 'hoppers hatched from eggs of last season. They were struggling to get out of the earth in a very lively manner. It seems that the nest had been broken up by the spade or plow, for which reason the creatures could not get out of the nest. This shows the advantage of breaking up the soil where the grasshoppers deposit their eggs, as recommended in the government reports by the Entomological Commission. These very interesting young "'hoppers" will be sent to Dr. Packard for examination.—[*Salt Lake Daily Herald.*

CHAPTER II.

THE ROCKY MOUNTAIN LOCUST IN MONTANA IN 1880.[1]

On the 4th day of July I left Omaha, Nebr., for Saint Paul, taking the Chicago and Northwestern Railway and the Sioux City and Saint Paul Railway, going by way of Sioux City. At Saint Paul I obtained a pass over the Northern Pacific, which carried me to Green River, a stage station about 100 miles west of Bismarck, Dak. Here I made some collections of the various species of locusts to be found, and also of a few data concerning their movements during previous years. From this place the journey was continued by stage to Miles City, at the mouth of the Tongue River, where I again halted to make collections and inquire into the movements of locusts during previous seasons. At Fort Keogh I took passage on one of the Yellowstone line of steamers for Terrey's Landing, at mouth of Big Horn River, making collections at all wood stations and stopping places along the route, as well as at the Landing, where I remained about twenty hours. From this place the course taken was up the Yellowstone River to near Bozeman. During this portion of the trip several side journeys were made and some time spent in collecting specimens.

At Bozeman, where the longest stop was made, I took quite a number of side journeys into the surrounding country and mountains for specimens; and also spent much time in conversing with persons from various parts of the Territory in reference to the flights and habits of the locust both for the present and past years. From Bozeman the route lay down the Gallatin to its junction with the Madison and Jefferson Rivers, thence across a high, dry plateau and rocky valley, and again approaching the Missouri, which was followed until within about 25 miles of Helena. At this place considerable information was obtained concerning the past movements of the locust, and also numerous specimens of the native locusts collected at various localities in the surrounding country.

From Helena I went north to Fort Shaw, where I remained one day, and then joined a small hunting and scouting party going southeast into the mountains bordering the Missouri. While here I met a hunter and trapper who was on his way to Fort Benton in a small skiff. I joined him, floating down the Missouri to Benton, thus obtaining an excellent opportunity of studying the surrounding country and of collecting specimens. From Fort Benton I took stage to Fort Shaw, re-

[1] Report of investigations in Montana, by Mr. Lawrence Bruner, made under direction of Dr. Packard.

turning to Helena, and thence to the terminus of the Utah and Northern Railway, thus having made a pretty thorough tour of Central Montana and Western Dakota and through the heart of much of the "permanent breeding" region.

The Judith and Musselshell Valleys could not very well be reached under the circumstances, as at the time of my passing through no stages were running into either of them, and Sitting Bull, with his followers, occupied a large portion of the country bordering these two basins.

At noon, July 7, while crossing the country lying along the Cheyenne River of Dakota, locusts were seen in the air in small numbers, flying to the south-southwest. A few were also seen on the ground. On inquiry, nothing could be ascertained in reference to their place of breeding or numbers. It was supposed that they had hatched in the Red River country, and west on the high and dry table-lands. I have, since my return, traced this swarm into Nebraska and Kansas, where they have spread over about half of these States, and are so scattered that they are hardly noticeable. No damage is recorded as having been perpetrated by them. From this locality west but few locusts were seen, and I will take the notes as they occur in my note-book.

COUNTRY BETWEEN BISMARCK AND FORT KEOGH.

Hoppers—natives—numerous at Green River and Beaver stations, 1879. Locusts breeding on high, dry flat north of White Buttes. Left in early part of July to the southwest. None this year. Could be destroyed at this locality by spring fires. Was unable to ascertain from which direction they came, but it was thought they came from the northeast. Also at mouth of Powder River numerous eggs were deposited by a swarm from the northeast (according to the stage-driver). These eggs did not hatch this spring. No cause known for this, but supposed to have been the severe winter—cold, without snow. During last winter at Fort Keogh the thermometer reached a point 53° below zero. Snowbirds were seen scratching out and eating the eggs at mouth of Powder River (stage driver). I also noticed various species of birds killing the native locusts. This list would include almost all the smaller species of birds inhabiting this section of country. The magpie and crow are among them.

At Fort Keogh, a private in the Army says that swarms of great extent were seen on Milk River in early August, 1877. Did not notice whether depositing eggs or direction they came or went. At Fort Custer, large swarms in August, 1878, from northwest—no definite information obtainable.

July 19, 1880.—A few young locusts (larvæ and pupæ) on river bank, 35 miles above Fort Keogh. These are principally *C. spretus* and *C. atlanis*. Could not have been destroyed by fire—too wet in early spring.

July 21.—Numerous *C. bivittatus* and other native species seen along

the bottoms south of the Yellowstone River between Junction City and Huntley's Landing. None, or very few *C. spretus*—not as common as in Nebraska.

July 22.—Hunter's Post-Office, 16 miles east of Stillwater. A small swarm of locusts breeding in hills north of the office in 1878. Left in latter part of July to the southwest. One small field damaged by them. Others flying over a week later to the south and southwest. Numerous swarms during 1875 and 1876 from west and northwest during July and August, and one earlier (about 1868). Nothing to damage, and no damage done.

Crow Agency.—No locusts breeding in vicinity of the agency since established on the Rosebud. A few flying over in 1878 toward the south. Came from the north and northwest. Claimed to have come from the Musselshell and tributaries, where they hatched in small areas. Every one speaks of them as coming from the north and northwest, where they are claimed to be found almost every year, if not permanently.

July 26.—Saw a few locusts at Countryman's Ranche, on the Yellowstone, a few miles above the mouth of Stillwater. Some *C. spretus* and *C. femur-rubrum;* also several species of others, as *Stenobothri*, *Œdipodæ*, &c.

July 27.—Very few locusts of any description on road between Stillwater and Fort Ellis.

July 28.—Visited cañon southeast of Fort Ellis. A few pupæ of *C. spretus* and several other Calopteni were found among the rank vegetation close to the Gallatin. Other species of *Acrididæ* were met with higher up the mountain sides, but they were nowhere numerous. Other insects were also quite scarce—too dry.

July 29.—Walked into the foot-hills north of Ellis. Found numerous young larvæ and pupæ of several species of Caloptenus, among which were *C. spretus* and *C. atlanis*. They were confined to ravines and damp localities where the grass was good. *C. bivittatus* was more evenly distributed, being equally numerous even to the mountain tops. Other grasshoppers, perhaps *Pezotettix Dodgei* and allies, were quite common.

July 31.—Nothing additional in reference to locusts.

August 4.—Met a "cattle man" who has just come across the country from Cheyenne, on the Union Pacific Railroad, by route to Fort Fetterman, thence to Fort Reno, then north along the foot-hills of Big Horn Mountains to Fort Phil. Kearney, thence down Goose Creek and across to Little Big Horn, down to Fort Custer, then up to Bozeman. No locusts and but a few natives were seen upon the entire route. This being almost through the heart of Wyoming and the south locust area, is quite conclusive evidence that there are but few if any locusts this year in the country traversed by this gentleman. He also informed me that he had made special inquiries in reference to locusts in adjoining sections and along the route, but that there were none. This entire area, he claims, has the appearance of being easily burnt over, and I do not

think that the same difficulties are present as in the greater portion of Montana.

August 5.—Met and talked with some Flathead Indians about locusts in the vicinity of Flathead Lake. They left there last fall. They reported locusts as being quite plentiful, but not many of the kind that "flies away." Some were depositing eggs and others flying southwest. One of them said that he saw locusts on the Judith nearly every year he was there (since 1870). They also reported migratory crickets as quite numerous in Western Montana and Idaho. I could not ascertain anything definite in reference to dates of appearance, direction of flights, and which way they came from, but obtained a little additional information in reference to native species, which he said became quite numerous at times. He also made a drawing of another variety of grasshopper, which he said was not at all numerous. Just what species he refers to I am at a loss to imagine.

Have just called upon the editor of the *Avant Courier*, from whom I obtained some information in reference to the movements of the locust swarms of 1867, 1868, and 1869, and also those of 1874, 1875, and 1878. These swarms visited the Gallatin Valley.

During the latter part of July and early August, 1867, immense clouds of locusts appeared from the southwest and came into the Gallatin Valley, alighting upon fields of grain, and remained over night doing much damage. On entering the valley their course was slightly changed toward the east, in which direction they disappeared, with but few exceptions, where small numbers were known to remain and leave their eggs. Of these few nothing further seems to be known, except that in the following spring a few small spots were partially denuded by the young—all confined to the high lands. The major portion of the swarm of 1867 continued its flights eastward and was soon lost sight of, at least to the inhabitants of Montana.

Again, in the summer of 1868, large swarms came into this valley from the same direction, but somewhat later in August. They remained and deposited their eggs over the greater part of Gallatin County in suitable localities, as hard, sandy hillsides. After they had deposited their eggs they died by thousands, which fact appeared very queer to the inhabitants, who were ignorant of their habits, and did not know that the locust's mission ended with oviposition.

The lay of this valley is rather peculiar, having once been the bed of a lake. On receiving an outlet to the north it gradually washed away at that end, thus forming an inclined valley, with a grade of almost 50 feet per mile. Hence the north end of the valley is about two weeks earlier than the south end. Early in the following spring those on the low lands hatched in great numbers, and took crops clean as they went, while farther up the valley the weather was more backward and wet, and the damage was much less. These, when they matured and had wings, left in various directions, but principally to the east. From

this time until 1874 and 1875 there was no damage done in this part of Montana, and but few locusts seen in the air. Hence, nothing like reliable data can be had in reference to their movements.

In the summer of 1874, during the months of July and August, great and destructive swarms poured in from the east, where it is claimed they hatched throughout the Yellowstone, Musselshell, and Judith basins; and to this effect I have much information from various soldiers who spent this and the previous summers in these basins.

Some of these deposited their eggs, while the majority continued westward and southward. Considerable damage was done in the spring of 1875 by the young.

From this time on nothing more was seen of the locusts in the Gallatin Valley until the summer of 1878; but the greater portion of the Northwest, the Judith, Musselshell, and the Big Horn countries, were overrun by swarms of them that were produced in these several sections during the summers of 1873, 1874, 1875, 1876, and 1877. Of the movements of these different swarms I could not obtain any definite information by which I could trace them as I did those of 1878, but obtained enough to enable me to partially keep track of them. They seemed to spread over the greater portion of the "permanent" and "sub-permanent" regions, as mapped out in the report of 1878, and finally over the entire portion known to ever receive invasions from this species of locust, attaining the maximum in 1875–'77, from which time they have been growing less numerous and injurious until the present, when but few small swarms remain in the entire area.

Again, in August, 1878, the Gallatin Valley was invaded by swarms from the northeast. None, however, remained to deposit eggs. They passed on to the south and southwest—probably the same swarms that invaded Idaho and Utah Territories from the north-northeast, of the same year, and which we saw during August while in these Territories. They came from the Judith and Musselshell Valleys and farther north, and are identical with those seen about one week previous near the Milk River and Missouri.

August 6.—Met a gentleman who informed me of the presence of locusts (*C. spretus*) in the vicinity of Butte, in western Montana. They were hatched there, but up to time of writing no great amount of damage has been done by them. Just how much territory they covered I could not ascertain, but do not think it great. Have been in this vicinity since and found but very few, hardly as numerous as they are in the Missouri River region of Nebraska and Kansas in years not visited by locust swarms. This district is drained by one of the tributaries of Hellgate River, a branch of the Columbia, and is quite mountainous. The entire surrounding country is a mining district, and but little farming is done. It is supposed that these few originated from the remnants of swarms that were hatched in the neighborhood of Flathead Lake and a few other isolated localities in the spring of 1879, and left

in a southwestern direction, depositing eggs at various localities on their course.

In glancing over the *Butte Weekly Miner* of August 3, 1880, I find the following local:

> At Walla Walla, Wash., whole fields of standing grain are being sold for from $5 to $8 per acre. *Some of it has recently been attacked by grasshoppers*, and some fell a prey to the scorching heat, but such grain, if cut in time, will make excellent hay.

From this I would infer that there are some locusts in Eastern Washington Territory and Oregon.

August 7.—Have learned no new facts to-day in reference to the Rocky Mountain locust, but have been studying the map in connection with my notes, and find that there are three principal directions by which swarms come into the Gallatin Valley, viz., southwest, east, and northwest. Those coming in from the east and southwest I have traced heretofore, but those coming from the north I have not; hence, will do so now. All that country lying to the north and west of Fort Benton to the base of the main Rockies is a suitable breeding-ground for locusts, and at times is partially overrun by swarms. It is during these years that, providing the wind is favorable, the Gallatin Valley is almost sure to be visited; but this vast tract of country, like all others in this the "permanent" region, is only occasionally occupied by them.

In the Gallatin Valley the young begin to hatch about the middle of May—soon after the snow is off the ground—and continue to appear until the 1st of June, according to locality and melting of incumbering snows. After hatching, it has been noticed that the majority of the little "fellows" move in the same direction taken by the parent swarm (?)—perhaps from inborn memory or instinct. With a knowledge of this fact, the farmers construct ditches, where they do not already exist, in their course, and turn water into them. When the little locusts come to these they jump into them, and are washed along by the current to places where obstructions are so placed as to form an eddy. Above these eddies are fastened vessels filled with coal-oil, and so arranged that a continual dropping is obtained. This oil on the surface kills the young. Another method adopted is simply the fastening of bags, into which the 'hoppers are washed and drowned by the current. These two methods have been so successfully used as to save the greater portion of the crops in some localities where employed. In fact, I am informed that the farmers do not dread the young any more than we do in the more thickly settled portions of the States. Other means have been tried, but with indifferent results; and since there is seldom any necessity of constructing other ditches than those already made for irrigating purposes, the labor and cost is trifling. It is claimed that one gallon of coal-oil, at the cost of 75 cents per gallon, will kill several bushels of locusts. Birds, too, are becoming more numerous than formerly, and hence the destruction of locusts (young and old) by this means is increasing.

The young attain their wings during July, when they leave either to the southwest, east, or north, very seldom remaining to deposit their eggs.

During the summers of 1874 and 1875, as well as 1878, the locusts were so numerous at Bozeman that they entered stores and eat holes in the various kinds of goods. They came from the northeast to east, probably from the Judith and Musselshell basins, and north. Some were hatched on the Judith in 1874 and left toward the west and southwest (Goodale). Others came from the Milk River and north. One company of troops going through this section mentions the appearance of vast swarms of locusts coming from the northeast and going southwest. They were coming and going for more than one week. This was in August, 1878. Some of the men with whom I spoke say that the roar of their wings was much like the sound of a tornado.

While at Fort Keogh, the post gardener told me that one time a friend of his was up in the Big Horn Mountains and saw "the grasshoppers piled up 2 feet deep on the surface of snow-drifts"; but he could give no dates or particulars in reference to size or species of locusts.

August 10.—Between Bozeman and Helena the country is mostly high and dry, with many rocks scattered about over the surface. The valleys are small, but fertile. This year there are but few migratory locusts in this section, not even as many as of the various other species. Outside of the genus Caloptenus, the natives are mostly frequenters of high, dry soil, where they can do no particular damage.

August 11.—Have been out collecting locusts, but succeeded in finding only two or three *C. spretus.* I did, however, procure about twenty-five species of natives, all of which are quite abundant. These are almost all mature, but I noticed a few that had just hatched, and others in various stages of growth between the newly hatched and mature pupæ. I also found a few of the migratory crickets.

To-day (August 12) was spent walking about among the farms in Prickly Pear Valley, northeast of Helena. No *C. spretus* seen, but numerous natives on the dry grounds bordering the valley. Am informed that these never venture upon or do damage to crops. They are partial to wild land, and particularly such as is high and dry.

The migratory locust has been an almost permanent resident of this valley for the space of five years, or from 1874 until the fall of 1879; and it has been claimed by some that early this spring quite a large area of country was occupied by young just southeast of Helena, in the foot-hills. This I hardly think true, since I visited the locality and found only natives (a few *C. atlanis*, *C. femur-rubrum*, *C. bivittatus*, and several smaller species). These were confined to that portion of the foot-hills just below timber line.

The migratory locust first appeared in this valley in July, 1874. It came from the east in great clouds, left eggs, and for the following years (1875, 1876, 1877, 1878, and 1879) was a permanent resident of this

section. During the summer of 1875 it was most numerous and destructive. Am informed that this year the crops were nearly all destroyed, and even about one-half of the hay crop fell a prey to them—*i. e.*, the young. They were full fledged by the middle of July, and left toward the south and southwest. This was true of every succeeding season in which there were locusts. They dwindled down, year after year, until this year there are not enough of them to procure cabinet specimens. They kept coming in from the east and northeast every year until 1878. This swarm originally came from the Judith and Musselshell, where they were hatched in the spring of 1874, their progenitors having remained in the last-named country during 1871–'73 (Trapper). In the Prickly Pear Valley no decided steps were ever taken to destroy them. Ditches were employed by a few, and portions of crops saved, but the majority of fields were forsaken to the enemy.

An old German told me of a method he had used for several days to keep off the winged locusts, but which he said was "no good," for one morning his grain was all gone. The plan was as follows: Two men on horseback rode through the field dragging a rope between them, thus starting the locusts flying.

In 1868, at this place (Helena) there were locusts. They came from the east (Minnesota, as my informant remarked), and were so numerous that, as he claims, while driving oxen he "couldn't see the front yoke." Some eggs deposited, but could learn nothing of them the following season.

August 16.—Last summer, just southeast of Helena, in the foot-hills, quite a lot were hatched from eggs left the previous fall (1878). They covered an area about 3 miles in length and between 1 and 2 in width. The young at first appeared quite lively, but soon became rather torpid, the effect of much rain and snow. Large numbers of them died, and about the time the remaining few reached the pupa stage a large flock of curlews (*Numenius longirostris*) alighted on the locust area and destroyed them.

A miner, in speaking of locusts in 1874, says they used to congregate in great numbers in and about the sluice-boxes and on the gravel heaps during the evenings. By morning they had become so benumbed by cold that they could not move. "One morning," said he, "I turned on the hose, and in less than twenty minutes had succeeded in lodging, at least calculation, twenty bushels of 'hoppers in my neighbor's garden." They revived with the heat of noonday.

August 17.—No migratory locusts between Helena and Fort Shaw.

During the summer of 1866 there was an invasion at Virginia City from the south. Considerable damage was done to those living in the valley, while those living up on the foot-hills closer to the mountains, escaped, the wind carrying the locusts over them.—(John R. Drew.)

All the incoming swarms in the vicinity of Virginia City come from the south and southeast, and all outgoing swarms either take a southerly

course toward the Snake River or a northeasterly course to the Gallatin. Mr. Drew also gave me a few additional facts in reference to the swarm of 1868 in the vicinity of Helena, where they "came in from the north," as he states, "striking the buildings on the south side of the street, and fell down in such large numbers as to form 'drifts' of 'hoppers." They left some eggs, as in fact he claimed they do every year that they visit any section in this part of the territory. He supposed they were hatched in the vicinity of Flathead Lake and the eastern foot-hills of the Rockies north of Sun River.

After this the next swarms that he noticed were those of 1874, coming in from the east to southeast. From this on they were with them annually up to last year, when they disappeared to the west and southwest. The damage during this succession of years was great in the Sun River Valley, but the years of greatest suffering were those between 1874–'78. Says he: "In the spring of 1877 the young were so numerous that the ground was completely hidden by them in many localities." The previous summer, 1876, great swarms came in from the southeast, and deposited their eggs in quantities that could hardly be believed. The young were hatched early in May, and left as soon as attaining wings, in the latter part of June and early July. They flew to the west and southwest.

Here similar methods were adopted to those mentioned heretofore for the destruction of the young, viz., ditches, &c. Some farmers do not put in their crops until the young are all hatched and they have cleaned them off by burning straw, &c., over the fields; but this plan is not a good one, since in this country grain requires the entire summer to mature, and if not put in early in spring is liable to be hurt by early frosts.

At this post similar methods were employed for the destruction of the young, and, while the incoming swarms threatened, an occasional discharge of muskets and artillery seemed to produce the desired effect of keeping them in the air. I am informed that in close proximity to the cannons the ground was strewn with the bodies of dead locusts, probably killed by the shock occasioned by the discharging guns.

I hear that a few migratory locusts have been seen in the vicinity of the south fork of Sun River, about 40 miles west of Shaw, but over a very limited area.

August 19.—Between Fort Shaw and the Missouri River lies a large dry flat, on which at various times numerous locusts have bred, but this district, like all others, appears to be entirely free from them this season. In fact, there are fewer of *C. spretus* in Montana this season than of any other species.

August 20.—During three hours' hunt for locusts I found but three *C. spretus*. Caught many for trout fishing, but with above result. No damage mentioned in this vicinity since 1876. Came from the southeast and east. But little farming done here, and not much grazing.

August 23.—A few locusts (*C. spretus*) on the low bottom lands 12 miles north of the Fort Shaw and Camp Baker crossing. Not numererous enough to do any damage. Hatched here. No grazing or farming in the vicinity.

August 26.—A few locusts on table-land between mouth of Sun River and Great Falls of Missouri. Numerous Pezotettigi in cooleys branching out from cañons.

Interviews with different persons who spend the spring and summer in the Judith and Musselshell basins all show that this year there are no locusts except natives in the country bordering on and drained by these two rivers and their tributaries. Several say they could scarcely find enough 'hoppers to bait for fish. During the latter part of July and early August, 1876, while in these two valleys, saw numerous and large swarms moving west for three weeks. They were hatched in this country and north. Also swarms in August, 1878, moving south, supposed to have been hatched in the British provinces, north of Assiniboine. Also report of swarms occurring in these basins from 1873 to 1876—one year in particular, when they flew in such numbers as to obscure the sun for three days (Goodale). We cannot give the dates or direction of flights for these years.

Northwestern Wyoming was visited by swarms in August, 1878, from the northeast and flying to the southwest. They were so ravenous as to eat articles of clothing left lying on the ground (Soldier).

Report of a small swarm of locusts flying eastward through Wyoming along route of Union Pacific Railway last summer, 1879. Could ascertain no dates or particulars.

Reports from British America claim no locusts this year in the immediate vicinity of the line adjoining Montana; nor can I learn of any in the Milk River country. But in the spring of 1878 great numbers were known to breed both in the Milk River country and the British possessions adjoining. Never saw many locusts in the mountains of British America where he was prospecting for a number of years (Miner).

From these data it would appear that the present year finds the entire Northwest comparatively free from this great pest, and probably the entire country. Of course, as I have already mentioned, there are a few isolated areas over which small numbers of this species still exist; but those which I visited are so small and the locusts on them so few that I do not think they will migrate or increase to sufficient numbers to do damage for the next three or four years, and perhaps for a much greater length of time. It is true reports have come from several localities that crops were partially destroyed by "grasshoppers," but might they not be other species? If they were of the migratory kind, I should think that we should hear more of them than we do.

ENEMIES OF THE LOCUST IN THE NORTHWEST.

Some might think that in this out-of-the-way country the locust would be entirely free from enemies of all kinds, but such is not the case.

During my sojourn in Montana I noticed several species of Tachina flies, wasps, ichneumons, and other insects preying upon the common species of locusts, and I am satisfied that they must also attack the migratory individuals. Besides these there are several varieties of small red mites that are occasionally found attached to various species of locusts, crickets, katydids, and even beetles. These are the young of a class or group of mites that, as a rule, live upon the eggs of insects, particularly those of Orthoptera.

Birds are just as much enemies to locusts here as in the Lower Missouri region, and almost every species found in these parts is known to feed upon and destroy myriads of them during locust years. Even such birds as the cat-bird and crow-blackbird have been known to eat many of them. Ravens, too, and magpies are very fond of their eggs, and are often seen during winter to dig up and eat great numbers of them. While coming down to the terminus I noticed a magpie capturing and eating quite a number of several species of *Œdipodae*. He was fully as agile and interested in the work as a sparrow would have been.

Besides birds and insects there are quite a number of other animals in Montana and the Northwest that do a good work in destroying locusts. I refer to skunks, badgers, chipmunks, and like animals. Chipmunks, although animals thought to be strictly vegetarians, are great insect-destroyers. I have at various times surprised the little striped fellows while they were sitting on a log and gnawing away at a grasshopper or katydid which they had captured, no doubt to vary their vegetable diet. At other times I have also seen them in pursuit of insects. That these animals are of considerable aid in the keeping down of noxious insects there can be no doubt, since in this part of the country they are very numerous. Snakes, toads, and lizards, too, eat many insects, and no doubt capture many locusts; while mice of different kinds assist a little. Then add to the work of these natural enemies that of diseases, climatic influences, &c., and we have quite an army of enemies at work trying—though not intentionally—to keep in check this pest.

Since I have never seen a description of the method of depositing eggs by Tachina flies on the bodies of locusts,[2] I will give it here. It is as follows: A female fly as soon as fertilized skims over the surface in search of suitable hosts on the bodies of which to deposit her eggs, and thus continue in them her kind. At last she spies a good healthy looking locust, may be one of the migratory species, or may be only a native, nevertheless it is just to her liking, and she silently alights upon a spear of grass or upon the ground close by to wait until the 'hopper, unconscious of the lurking enemy, launches into the air, when she is upon him, and has dropped a minute egg upon his body between his wings. This, if not destroyed, is soon hatched and the maggot eats into the locust's body, where it continues to eat and grow until it is fully fed and ready

[2] A description of the method will be found in the 7th Mo. Ent. Rep., p. 179, and in the first report of the Commission, p. 319.

to change to the pupa form. By this time the locust has become exhausted and dies. Frequently as many as two and even three maggots are reared in the body of a single locust. Occasionally the fly has to try a half dozen or more times before she succeeds in depositing her eggs, as the locust, as soon as it is aware of her presence, closes its wings and drops to the ground.

I have seen these flies so numerous in some parts of Western Dakota and Montana this past summer that for each 'hopper that flew up there were from three to five flies to follow. Of course but a small per cent. of the eggs of this enemy of the locust ever mature, otherwise the locusts would soon disappear from the face of the earth by this insect's work alone. The reason the fly chooses the moment the locust is on the wing for depositing her eggs is quite obvious. If she were to deposit the egg upon any other portion of the body than between and under the locust's wings the locust would be liable to scrape it off; besides at this spot is situated the softest portion of the body. I consider the ravages done to the locusts by this fly one of the reasons that they migrate.

Notwithstanding the great numbers annually destroyed by natural means, we can by no means depend wholly upon these remedies for the extermination of this destructive plague, the migratory or Rocky Mountain locust. We must be on the alert and do all in our power to assist, by various means, these, our friends, in keeping within bounds this and all other insect plagues. It is true that under favorable conditions nature soon balances herself, but when unnatural conditions appear this equality is broken. So all must unite in again restoring this change to its original equilibrium.

TOPOGRAPHY OF WESTERN DAKOTA AND MONTANA.

The greater portion of country lying west of the Missouri River and east of the main divide of the Rocky Mountains is composed of high table-lands, the greater portion of which is sparingly covered by a short growth of bunch and buffalo grasses. These grasses seldom attain more than a foot in height, and always mature long before frosts, giving a dreary, desert-like appearance to the country even before the autumn approaches. The valleys are few and narrow, seldom having streams of running water flowing through them; and lakes and ponds are rare, but when present are alkaline. The entire country is fit for nothing but grazing, save very narrow strips along the margins of the larger streams, which can be farmed if irrigated.

A large portion of western Dakota and eastern Montana is so cut up by cañons, and is so destitute of vegetation, that travel through it is impossible. These are called bad-lands—a very correct name for them, too, for in them everything has the appearance of having once been baked and burned. The soil is variegated with all sorts of colors that could be produced by heat. Sulphur, lime, and iron are present in their

combinations in large quantities, but I do not know exactly to what geological period these formations belong. The rocks have the appearance of those of the Fort Pierre and Dakota groups, and many of the formations contain large quantities of gypsum and pyrites of iron, as well as large numbers of geodes and globular concretions varying in size from the fourth of an inch to over a foot in diameter.

All the farming land in the section west of the Missouri could be contained in a State the size of Delaware. It is mostly confined to the valleys of the Yellowstone, Big Horn, Tongue, Judith, Gallatin, Madison, Jefferson, Sun, Smith, Prickley Pear, Missouri between the junction of the three forks (Madison, Jefferson, and Gallatin) and Fort Benton, and several other smaller streams. Along these streams there are many localities where the mountains encroach so closely as to leave no bottoms, and hence the amount of arable land is reduced. The next rise of land is just fair for grazing, but as a rule the grasses on these places are much like those on the table-lands and more elevated regions—short and in clumps.

The mountain chains are numerous, and occupy about one-tenth of the entire area of the Territory, I should judge. Among these there is much good grazing, and now and then a small patch of tillable land. The grazing, however, among these ranges is only good during the warmer parts of the year, when the snows are off.

It is over the greater portion of the entire country that the locusts deposit their eggs, only avoiding the higher points and timbered portions of the mountain ranges and the very lowest of the valley lands where it is too wet. This entire area is admirably suited for them, since, during the summer and fall months, the country is dry and the soil hard, offering just such conditions as are generally chosen by them under which to deposit their eggs.

Over this vast area I am sorry to say that burning would be impossible except over a very few small districts in the extreme eastern portion where the locusts do not often breed. From the time the snows begin to melt until the grass is almost fully grown, this vast district is almost daily visited by rain and snow storms, and the country where level is one vast mud-hole. The young grass, too, seems to begin to grow even before the snow melts. At any rate by the time the young locusts appear the country is quite green and fires would not run. This was attested by all with whom I spoke in reference to destroying the young by prairie fires in spring. So it appears that other means would have to be adopted to destroy the young in Montana.

Winds have much to do with the direction taken by swarms, but not with their migrating. Rains cause them to alight. Mountain ranges, river courses, and valleys also seem to slightly change their courses, and form thoroughfares along which swarm after swarm passes year after year.

CHAPTER III.

THE ROCKY MOUNTAIN LOCUST IN WYOMING, MONTANA, ETC., IN 1881.

WEST POINT, NEBR., *January* 10, 1882.

SIR: I have the honor to report the following in reference to my trip through portions of the West and Northwest, as entomological agent for the United States Department of Agriculture, in studying various insects injurious to agriculture, and more particularly in accumulating additional data in reference to the Rocky Mountain locust (*C. spretus*).

At the time of receiving my appointment, I was in Greeley, Colo., and at once went to work by making excursions in various directions into the surrounding country. These were made while connected with the construction work of several new lines of railroad which were being built by the Union Pacific Railroad Company, hence were of no expense to the Department other than my salary. Afterwards I also accompanied Professors Lester F. Ward and C. A. White, of the United States Geological Survey, in several of their drives into the country adjacent. These short excursions took me over a considerable area of the farming portion of Colorado, and also out into the plains lying to the eastward down the Platte and its tributaries.

Upon receiving further instructions I proceeded west, working along the line of the Union Pacific Railway, which was left from time to time to make short excursions into the adjoining districts, where it was reported the locusts had done damage to crops and vegetation generally, and this, too, within the past few years. The principal of these was that of following up Ham's Fork of Green River to Hodge's Pass, and about 10 miles down the western slope towards Bear River. In making this trip I succeeded in establishing some important facts in reference to the movements of *C. spretus* in this part of Wyoming, and also in adding somewhat to our knowledge of its natural history, which may be of value in fighting it hereafter.

I then proceeded to Ogden, Utah, where I took the train north over the Utah and Northern Railroad, into the valley of the Snake River, where I obtained data in reference to the movements of this insect in that part of Idaho; thence working northward and westward through the valleys of the Big Hole, Deer Lodge, Hellgate, and Missoula Rivers, thus taking in a large portion of Montana hitherto not visited by any member of the Commission.

At Missoula many data were obtained in reference to the movements of locusts in that portion of Montana. From here I proceeded on horseback down the Missoula Valley, to where Mullan's Wagon Road crosses the Cœur d'Alène Mountains, and thence across the mountains through Northern Idaho into Washington Territory. Here I obtained what data I could, and then worked my way southward across the Spokane Plateau to Walla Walla, the section visited by small swarms of locusts within the past few years. Leaving Walla Walla, my homeward journey lay down the Columbia to Portland and Astoria, where I was obliged to lie over for four days, waiting for the next steamer to San Francisco. During this period I went over to Fort Canby, and spent my time in making a collection of mosses and ferns, which I herewith send to the Department. I also obtained a few land shells.

In making this trip quite a number of favors were extended by the following corporations and individuals: Union Pacific Railway (Oregon short line), Gilmer & Salisbury, half rate; officers and troops at Fort Missoula, transportation and favors; Edwin D. Dukes, hospitalities; Northern Pacific Railway, pass; Oregon Railway and Navigation Company, passes; and officers at Fort Canby, hospitalities. Besides these I am under great obligations to many others for aid in accumulating locust data, as well as those relating to various other insects.

I have also embodied, at your request, a summary of the probabilities for the present year, 1882.

Respectfully,

LAWRENCE BRUNER.

Professor C. V. RILEY,
United States Entomologist, Washington, D. C.

GENERAL REPORT ON THE ROCKY MOUNTAIN LOCUST.

It is not my intention in this report to describe all of the facts gleaned or to note the work done by the Commission and others in reference to this insect. I will, however, give a condensed account of the more important points that directly treat upon the means of their diminution and prevention in future, with a few additional traits noticed during the past season. Of course it will be necessary occasionally to allude to matters mentioned in the annual reports of the Commission, and also to other records relating to the life-history and depredations of this and other locusts. Before entering upon a discussion of this subject, I will give a brief history of this insect and its depredations in various portions of the country which it visits in the course of its migrations.

Up to the time of the settlement of portions of Eastern Kansas, Nebraska, and part of Minnesota, comparatively little was known of locust swarms and their magnitude in North America. At long intervals only

would a notice of the appearance of swarms of "grasshoppers" reach the public through some newspaper or magazine account of travels in these wild and unsettled regions. These, as would be imagined, were mere notices of their having been seen, without any attempt at a description of them or anything relating to their movements. It is but a few years since that they even so much as had a name of their own. (Walsh in 1866.) But, as the country in the then Territories above mentioned began to be settled they became more and more known, as swarms made their appearance from time to time and occasionally alighted upon and destroyed fields of grain and gardens. It was not, however, until within the past fifteen years that they began to attract much attention by their ravages. I now refer more particularly to Kansas and Nebraska, with adjoining portions of Iowa and Missouri. Minnesota, too, was but thinly settled in those parts frequently visited, while Dakota was but little known. True, locusts had several times been known to do damage to vegetation in Manitoba and Minnesota as early as 1819, when they were said to have been very numerous.

Whether swarms of locusts visited these districts as often prior to their settlement as they have since, it is not easy to ascertain; but that they did so occasionally is quite certain, and that, too, in numbers equally as great or even greater than in our time. In speaking with an old Omaha Indian during the summer of 1876 in reference to grasshoppers, he said that about twenty-five years previously he had seen them so numerous in the Elkhorn Valley and adjoining parts that they ate nearly all the grass for many miles around. In fact, the Indians could scarcely find enough grass for their ponies. This was while they were out on a buffalo hunt. He also stated that at other times they had met with the locusts while out on their hunts, but never in such great numbers as at this one particular time. He said they came from the mountains "far off," at the same time pointing up the valley to the northwest. Last year while in Montana I also learned from Indians that at times, many years ago, the locusts were exceedingly numerous in the valleys of the Yellowstone River and its tributaries; and that on several occasions they had been so numerous as to devour most of the vegetation, and thereby to cause the buffalo to seek food in other parts. When asked about their flights, one old fellow (Indian) intimated that he had seen them fly in numbers sufficiently great to obscure the sun. It might be questioned whether this information obtained from Indians can be relied upon as of value. To this I will answer "yes," for all Indians are very close observers and remember quite accurately all incidents that are in any way connected with their modes of life, and particularly is this true while out on their hunts. A few had even noticed that the locusts were attacked by a kind of fly, which deposited its eggs between their wings.

Does the settlement of a country and the planting of new species of vegetation ever have the effect of drawing to it insect enemies from afar? and, if so, to what extent is this true? This is a question that

undoubtedly has presented itself to the minds of more than one entomologist and tiller of the soil, and is worthy of consideration in this connection. Before discussing it, however, let me give a short description of the preferences of climate, altitude, vegetation, surface configuration, &c., that this particular species of locust possesses in comparison with that chosen by others.

If we run our eyes over the map of North America and set aside all that portion contained between the meridians 103° and 117° west of Greenwich, and from the parallels of latitude 40° to 53°, we have the permanent home of this insect pretty well before us. It is all considerably elevated above the surrounding country, treeless over the greater portion, and also arid, thus agreeing to some extent with the locust-inhabited areas of Eastern Europe, Northern Africa, Western and Southern Asia, Central Australia, and portions of Central and South America. Now, what is there in these peculiar combinations of surface and climate and elevation that should produce the unwonted increase in numbers of a few particular species of widely different locusts? As we are already aware, all these insects become exceedingly numerous at intervals, and at such times leave their breeding grounds, or, more properly speaking, their native habitats, and fall upon the adjoining fertile country, where they cause great depredation, and in many instances even pestilence and famine. That this great increase is in some way connected with their migratory habits we know, but just how it was brought about in the first place we cannot say. As shown in one of the reports of the Commission, these invasions, *id est*, the general invasions of the entire country subject to their visits, appear to follow at intervals of about eleven years.

The reports of the Commission which have already appeared have so thoroughly described the nature and habits of this locust that I need not dwell upon its natural history or mode of migrating. That it is thoroughly migratory by nature cannot be doubted; for, at almost any point in the Permanent Region during the months of July, August, and September, on fine sunshiny days, a few of these insects can be seen on the move. Even a single family or the progeny of a single female will move from the locality where it hatched to some other point in this native habitat or adjacent to it.

If we reflect for a moment as to the surface configuration of the different countries from which at times invading hordes of locusts come, we shall notice that they are all pretty much alike, and that they are also, as a rule, destitute of timber and rank vegetation of any kind. They are all more or less elevated plateaus or table-lands, partially clothed with bunch grasses and dwarfed shrubs, which grow in clusters. The air is dry and bracing in its nature, and the winds which sweep over them are brisk. Taking into consideration these peculiarities of the various locust countries, it strikes us that only in a country of such a character can swarms of locusts originate and continue to exist in uncommonly great

numbers; and if this be true, changing these characteristics would necessarily result in their diminution, unless they really can continue to exist in such immense numbers in a region the surface of which is different from the foregoing. Judging from experience and from the past history of this locust, I should say that it would not and cannot continue under such changed conditions. For, if it could breed only in limited areas, it would of necessity become less numerous. Also, when traveling it would become more scattered, and would then be more apt to be kept in check by locust-feeding birds in connection with insects and other enemies which lurk in the recesses of forests and about groves and meadows. Always with the advance of settlement birds and insect-devouring animals of a certain class make their appearance, and do much towards keeping in check these pests. As examples of these I have the pleasure of introducing the robin, quail, orioles, sparrows, bluebirds, and other species that love to hang about the abodes of man—all of which are great insect-destroyers.

Not only in the above ways, then, will advance of civilization and the settling of this area tend to diminish the locust in numbers, but it will also prevent their increase.

As already intimated, there is a tract of country in the West and Northwest which, by its peculiar characteristics, is especially adapted to the modes of life of this locust; hence it has been termed the Permanent Region by the members of the Commission heretofore referred to.

Although this insect at times visits and breeds throughout the greater portion of the country lying west of the Mississippi River and east of the Cascade range of mountains, it is partial to a particular portion of this vast area that possesses peculiar climatic conditions. This region can be bounded as follows: On the east by a line beginning on the south, at the junction of the thirty-seventh parallel with the one hundred and sixth meridian, and running in a northeasterly direction to the ninety-ninth meridian on the forty-fifth parallel, whence the course changes to the north until the boundary line is reached, where it inclines to the northwest in a curve and strikes the fifty-third parallel at about the one hundred and third meridian. The northern boundary is the commencement of the trans-continental timber region of British America. On the west this region is bounded by a line nearly coincident with the one hundred and seventeenth meridian, sometimes running to the east, and at other times to the west of it, and towards the south making an abrupt angle to the southeast to avoid the desert regions of southern Nevada and a portion of southwestern Utah. The features of this entire region, or at least of those portions of it chosen by this locust as breeding-grounds, are its comparative aridity and freedom from timber.

This region is divided as follows into several districts that differ in surface configuration: The Mountain Region, the Plateau Region, the Region of Plains, and the Basin Region.

The Plateau Region, which is generally termed the Colorado Plateaus,

"extends from southern Wyoming through western Colorado and eastern Utah far into New Mexico and Arizona. They are bounded on the north by Wind River and Sweetwater Mountains, on the east by the Park Mountains, on the south by the Desert Range Region, and on the west by the Basin Range Region." This region is "chiefly drained by the Colorado River; but a small area on the northwest is drained into Shoshone River, another on the northeast into the Platte River, still another on the southeast into the Rio Grande del Norte, and finally the western margin is drained by the upper portions of the Sevier, Provo, Ogden, Weber, and Bear Rivers.[3] The general elevation is 7,000 feet above the level of the sea, varying from 5,000 to 12,000 feet. The ascent from the low desert plains on the south is very abrupt, in many places by a steep and almost impassable escarpment."

The streams which traverse the region have their sources in the Wind River Mountains on the north, in the Park Mountains on the east, and a number of tributaries come from the west. In their courses through the plateaus they run in cañons. These cañons are profound gorges corroded by the streams themselves. The "country rock" is composed of sedimentary beds nearly horizontal. * * * The region is also exceedingly arid, but the mountains that stand on the rim of the basin precipitate a large proportion of moisture, and in this manner streams of comparatively large volume head in the mountains, run through the plateaus, and descend rapidly to the level of the sea, while the country through which they pass is very meagerly supplied with moisture.[3]

The Mountain Region comprises the mountainous portion of Northern Wyoming, part of Central Colorado, all of Idaho with adjoining portions of Nevada, Oregon, and Washington Territory, also the western half of Montana. This region is composed chiefly of high ranges of mountains, most of which are partially clothed with forests of coniferous trees. There are numerous streams of considerable magnitude. These have their sources high in the mountains where there is much rain and melting of winter snows. Their lower courses lie along beautiful and richly carpeted valleys that are for the most part destitute of timber, and are bounded by low foot-hills covered with bunch grasses and artemisias. This region in the lower portions is also quite arid. Within this region there are also quite a number of low basin-like valleys that formerly were occupied by lakes. These are for the most part richly clothed with grasses and other low vegetation, and are generally drained by some mountain stream. They all lie northward in Montana, Idaho, and Washington Territory, and are of considerable elevation, varying from about 3,000 to 7,000 feet above the level of the sea.

Sloping eastward from the foot-hills of the Rocky Mountains towards the Missouri and Mississippi Rivers is an extensive tract of country known as the Plains. It is for the most part a comparatively smooth, treeless tract covered by sparse vegetation, mostly grasses and herbs that grow in clumps or clusters. The climate varies in temperature as we pass from east to west, and from south to north. The region is

[3] Maj. J. W. Powell: Preface to Geology of the High Plateaus of Utah.

arid, and has comparatively few water-courses running through it. But little rain falls during summer, and evaporation is great. As we proceed northward the stunted bunch grasses become more luxuriant, and the climate cooler. The streams that run through this region have their fountains in ranges of forest-clad hills and mountains, and, unlike those of the Plateau Region, wind along broad and fertile valleys that are bounded by gently sloping hills. These valleys are also adorned in most places by clumps of willows and other deciduous trees and shrubs; and in many of these broad sea-like valleys are to be seen some of the most beautiful pictures of the West.

In addition to the three regions above mentioned, there is another section that we will call the Basin Region. This region is situated between the Wasatch Range on the east, and Sierra Nevada Range on the west, and is drained by streams running into lakes, of which Great Salt Lake is the chief one. This basin region is separated from the others by ranges of mountains and high plateaus, and is one of the most fertile portions of the entire Rocky Mountain Region. The foot-hills and valleys lying to the eastward are decorated with beautiful flowers and rich grasses, while to the westward it gradually shades off into the desert regions.

All the country comprised in the above-described regions is at times overrun by swarms of this destructive locust, and possesses such climatic and other conditions as are best adapted to its life and great increase.

It is quite evident that a country the surface of which is so varied and extensive must also possess a varied climate, and that this is partly true we are aware, at least as far as heat and cold are concerned. But we must take into consideration one peculiarity of all this extent of country, viz., its aridity. We have arid and high plateaus, arid mountain valleys, the plains are arid, and an arid interior basin. We are also aware that *C. spretus* thrives equally well in all of these districts where the aridity is not too great, and where the annual precipitation does not exceed 16 inches.

Maj. J. W. Powell also describes the lands of this region as those which are irrigable, pasture lands, and timber tracts. Besides these there are deserts, bad lands, chaparral lands, and lava beds.

Of these various regions, as determined by surface configuration, the irrigable and pasture lands are those chiefly chosen by this insect as breeding grounds. Hence the area of the Permanent Region comprises but a small per cent. of the arid regions of the West or of that part of the Rocky Mountain system where the annual precipitation is less than 20 inches, and still less when we confine it to the more humid portions of these districts as chosen in years of ordinary numbers of this insect.

Major Powell describes these regions as follows:

The irrigable lands and timber lands constitute but a small fraction of the Arid Region. Between the lowlands on the one hand and the highlands on the other is

found a great body of valley, mesa, hill, and low mountain lands. * * * Usually they bear a scanty growth of grasses. These grasses are nutritious and valuable both for summer and winter pasturage. Their value depends upon peculiar climatic conditions; the grasses grow to a great extent in scattered bunches, and mature seeds in larger proportion perhaps than the grasses of more humid regions. In general the winter aridity is so great that the grasses when touched by the frosts are not washed down by the rains and snows to decay on the moist soil, but stand firmly on the ground all winter long and "cure," forming a *quasi* uncut hay. * * * In a broad way, the greater or lesser abundance of the grasses is dependent on latitude and altitude; the higher the latitude the better the grasses, and they improve as the altitude increases. In the very low altitudes and latitudes the grasses are so scant as to be of no value; here the true deserts are found. These conditions obtain in Southern California, Southern Nevada, Southern Arizona, and Southern New Mexico, where broad reaches of land are naked of vegetation, but in ascending to the higher lands the grass steadily improves. Northward the deserts soon disappear, and the grass becomes more and more luxuriant to our northern boundary. In addition to the desert lands mentioned, other large deductions must be made from the area of the pasture lands. There are many districts in which the "country rock" is composed of incoherent sands and clays; sometimes sediments of ancient Tertiary lakes; elsewhere sediments of more ancient Cretaceous seas. In these districts perennial or intermittent streams have carved deep waterways, and the steep hills are ever washed naked by fierce but infrequent storms, as the incoherent rocks are unable to withstand the beating of the rain. These districts are known as the *mauvaises terres*, or bad lands of the Rocky Mountain Region. In other areas the streams have carved labyrinths of deep gorges and the waters flow at great depths below the general surface. The lands between the streams are beset with towering cliffs, and the landscape is an expanse of naked rock. These are the alcove lands and cañon lands of the Rocky Mountain Region. Still other districts have been the theater of late volcanic activity, and broad sheets of naked lava are found; cinder cones are frequent, and scoria and ashes are scattered over the land. These are the lava beds of the Rocky Mountain Region. In yet other districts low broken mountains are found with rugged spurs and cragged crests. Grasses and chaparral grow among the rocks, but such mountains are of little value for pasturage purposes.

After making all the deductions, there yet remain vast areas of valuable pasturage lands bearing nutritious but scanty grass. The lands along the creeks and rivers have been relegated to that class which has been described as irrigable, hence the lands under consideration are away from the permanent streams. No rivers sweep over them, and no creeks meander among their hills, the only water to be found on these lands being scattered and isolated springs and the little brooks which they feed. These, however, never join the great rivers on their way to the sea, being able to run but a short distance from their fountains, when they spread among the sands to be re-evaporated.

Within the Arid Region only a small portion of the country is irrigable. These irrigable tracts are low lands lying along the streams. On the mountains and high plateaus forests are found at elevations so great that summer frosts forbid the cultivation of the soil.

These lands comprise but a very small per cent. of the Arid Region under the present resources for obtaining the amount of water requisite for remunerative cultivation of the soil.

Throughout this Arid Region timber of value is found growing spontaneously on the higher plateaus and mountains. These timber regions are bounded above and below by lines which are very irregular, due to local conditions. Above the upper line no timber grows because of the rigor of the climate, and below no timber grows because of aridity.

Both the lower and upper lines descend in passing from south to north; that is, the timber districts are found at lower altitudes in the northern portion of the Arid or Rocky Mountain Region than in the southern portion. This is due to the decrease in temperature as we pass from south to north. The forests are chiefly of pines, spruce, cedars, and fir, but the pines are of principal value. Below these timbered regions, on the lower slopes of mountains, on the mesas and hills, low, scattered forests are often found, composed chiefly of dwarfed piñon pines and scrubby cedars.

Of course that portion of the Arid Region described as the timber-bearing region is much larger than that actually covered by forests; but this is to a great extent due to the destructive agency of fires that annually destroy inconceivable quantities of timber. These regions comprise from 20 to 25 per cent. of the Arid Region, though at least one half has been denuded or is kept bare by the above-mentioned agency. This region, too, is very much like the temporary region of this locust in the annual precipitation of moisture, and hence these bare portions are not so frequently chosen as localities for egg-depositing as are those, lying immediately below this line, that have been described as grazing lands.

The area of the Arid Region the altitude of which is greater than the forest region is comparatively small, and comprises mountain peaks and parts of mountain ranges that extend above the line of perpetual snow or rigorous climate. Very seldom do any of these locusts choose the warmer portions of this region as breeding grounds, since it is too uncertain and quite humid, although the greater portion of the moisture that falls here is in the form of snow and hail. Neither do they frequent the *mauvaises terres*, deserts, lava beds, or chaparral lands. Then we have remaining the two other regions as the true home and breeding grounds of this insect, viz., the irrigable lands and the grazing lands. Of course great numbers of locusts are annually bred within and even above the forest region of the Rocky Mountain system, but, as before stated, the humidity of this area is too great, and hence it follows that these cannot be as vigorous as those bred below and in a more arid climate. That this insect does not require nor seek a high temperature, we are aware from the condition of the climate in those portions of British America where it breeds in such overwhelming numbers.

This region, which is known as the permanent breeding-grounds of the Rocky Mountain locust, as before stated, comprises all that region west and north of the deserts where the annual rainfall is less than 20 inches, an area of about 300,000 square miles. Of course they do not breed throughout this entire region annually, nor on all the surface; but it is because they are always to be found in some portion of it in greater or less numbers, and because they can continue to exist year after year without becoming diseased, that this name has been given to the region.

As would be expected, a country as large as this must necessarily vary to some extent in its surface configuration, and in its general appearance; but, as a rule, it is composed of wide stretches of prairie interspersed with a few small timbered areas and snow-capped mountain ranges. It is watered by the great water systems of the Missouri, the Yellowstone, Platte, Colorado, and Columbia, with many minor rivers, along the fertile valleys of which the young locusts are reared from year to year in numbers sufficiently great always to keep the stock large enough so that with a few favorable years this entire area with the adjoining country can be stocked and overrun by ravishing swarms.

While the locust is capable of continuing its existence on any favorable portion of this Permanent Region, there are in reality but few portions of it that, on account of their extent, are adapted to its greatest increase. These are far apart, and at times are the cradles of swarms that visit different sections of the cultivated districts adjoining them. The largest, and by far the most important of these, is that of Central Montana and portions of the British Possessions immediately to the north. The boundaries of this area can be put down as follows: On the east a line beginning near the Black Hills and running north by the way of the mouth of the Musselshell River to the Saskatchawan River and the northern limit of true prairie. The western boundary is almost equivalent to the trend of the Rocky Mountain Range, coming as far south as the Sweetwater Basin of Northern Wyoming. In other words it passes from the Big Horn Mountains in Northern Wyoming in an almost direct line to Fort Shaw, and thence north as far as the prairies extend, taking in the valleys of the Gallatins, Jefferson, and Prickly Pear Rivers as side shoots. The next in importance and size is that of which the Snake River Valley is the center. This district comprises all of Central and most of Southern Idaho, portions of Northern Utah and a small part of Nevada and Eastern Oregon. A third area is that of Southern Utah and portions of Northern Arizona and New Mexico, with a part of Colorado.

From the former come all the locust swarms that devastate Manitoba, Dakota, Minnesota, and at times Nebraska, Iowa, and Kansas, with a small portion of Missouri. Oregon, Nevada, and Washington Territory receive most of their locust swarms from the second, while Utah and Colorado, with adjoining portions of Wyoming, receive theirs from both this and the third or that of Arizona and New Mexico. While these are the principal courses taken by swarms in leaving these several locust centers, they occasionally interchange swarms and then these localities receive calls from all three sections. Montana swarms cross over the range into the valley of the Snake River, by way of the Madison, and into the northern part of Idaho and Washington Territory by way of the Boundary Pass and Flathead Lake. Those of the Central region pass northeast into Montana, both by the Madison and by way

of Northern Wyoming, while the central and southern regions interchange swarms directly.

While it would appear that this interchange of swarms between these several centers was intentional, by a closer examination into the habits of this insect and the influencing agents in its migrations, we can readily see that such is not the fact. Nevertheless, every object is accomplished in this way that could be were they made from impulse or desire. By the interchange of swarms there is cross-breeding of unrelated and distant individuals, thus preventing the deteriorating influence of a long-continued interbreeding. Also, by having these widely separated regions of large area, moving swarms of great magnitude are enabled to recuperate from the fatigues of travel and rear healthy offspring, to return to their starting point when the favorable opportunity presents itself.

As irregular as appear to be the movements of swarms of locusts in the widely separated areas to one who has not given the subject a close study, it is, nevertheless, a conceded fact that they seem to have leading routes which they follow. So marked is this rule in certain localities that it is difficult to learn of any exceptions. An example of this nature is that of their movements on the Upper Bear River and in portions of Western Wyoming, where every swarm of which I could obtain any information came from the west and northwest and flew to the east, northeast, or southeast. They also appear to fly in great circles in several sections of the West. The cause of this phenomenon is the combined influence of prevailing winds and surface configuration on moving swarms. For an example of this peculiar movement we will take a swarm that leaves the great center of distribution in Montana towards the southwest by way of the Gallatin and Madison Valleys and low passes across to the upper waters of the Snake River. These, after entering this latter valley, follow down that stream to where it makes an abrupt bend to the west. Here the swarms generally divide, some continuing down the stream, while the remaining portion of the swarm works on south and southeast over the low mountains to Bear River Valley and into the great interior basin. Those which strike the valley of Bear River mostly turn up the stream and wend their way toward the east and southeast until the vicinity of Green River is reached, when they again slightly change their course by swinging to the east and northeast. From here their course is eastward to the Platte, when they again divide, a portion following up and the other portion following down this stream. The latter, after passing through the cañon out upon the plains, are struck by south and southeast winds and carried to the northeast toward the Black Hills, and from this point return to southern Montana and finally to their starting point. Those that follow up the Platte cross over the range by way of the various passes into Eastern Colorado, and either work south through this State into New Mexico, or drift out on the plains into Western Kansas and Nebraska,

where they become scattered and lost, except when in uncommonly large numbers as in the year 1866, when they came as far east as the settled portions of these States and did considerable damage.

Those that leave the northern portion of this great center and cross over the range into Idaho and Washington Territory, work southwest at first, then south through western Idaho and eastern Washington Territory, when they turn to the southeast and reach the central region, from which they return to the starting point by way of the Snake and Madison Valleys. These movements, however, occur, and for the greater part of their course lie, within the Permanent Region; hence they cannot be set down as the mode of travel in all portions of the country at times visited by their swarms, neither can they be considered as being the rule of their flights.

Locusts that follow down the Snake River enter eastern Oregon and work their way northward through this State and western Idaho with a portion of southeastern Washington Territory, and thence are carried by the prevalent winds across the Cœur d'Alène and Bitter Root Mountains into the valleys of the upper portions of Clarke's Fork of the Columbia. Here they continue working eastward through western Montana until they recross the Rocky Mountains into the great center of Montana and British America, thereby completing the circular movement. Of course these movements are only noticed in connection with the movements of swarms in different portions of the districts embraced, and, as just stated, for the most part are confined to the Permanent Region.

With these facts in reference to the movements of locusts in general before us, it will now be in order to mention some of the controlling agencies for the various actions of moving swarms; how it happens that they choose these particular routes just mentioned, why at certain times of the year the prevailing movements are in one direction and just opposite at another, and why it is that a change of wind or the advance of a storm or even a decided change of temperature from warm to cold brings them to the ground.

When locust swarms start for a flight to some other locality they, as a rule, follow a particular direction, which varies much in different sections of country, and at different seasons of the year. Any agency that interferes with this particular course has a tendency to bring the entire horde of them to the ground. They appear to have a purpose in view when starting, which, if interfered with, will cause much uneasiness on their part. It is not necessary for me to give any minute description of the general laws of flight, nor to dwell upon the influence of storms, changes of wind, temperature, elevation, climate, and surface configuration upon these. All these have been discussed at length in various newspaper articles and other sketches of which this insect with its history formed the subject. The reports, too, of the United States Entomological Commission are exhaustive on this portion of its natural

history. Suffice it to say that any sudden change of wind or of temperature will cause them to drop to the ground, where they will remain until everything is again favorable for continuing in their chosen course. Surface configuration, too, has much to do with the directions taken by moving swarms. Valleys, as a rule, are followed either up or down, while mountain chains of great elevation swerve them from their course, causing them to turn either to the right or to the left, according to the direction of the wind and the route pursued. Outside of the Permanent Region their movements vary somewhat from those within this region. After the first season's absence, all swarms appear to direct their course back towards this region, at least this is the case with those reared in the Temporary Region of the east. I have also noticed that in Nebraska, during the earlier part of the season, the prevailing direction taken by swarms is northward and westward, while later in the season it is toward the south. The turning-point is about July 15. Whether this is really the case, or whether it is due to arriving and departing swarms, I am not quite prepared to assert positively at present. That this is true, however, can easily be ascertained by referring to any work giving the data of locust flights for a succession of years in this district. However doubtful this may appear at present, it is nevertheless my opinion that it all depends upon the outgoing and incoming swarms, with perhaps an occasional exception brought on by change of winds, &c.; perhaps also the change in the direction of the prevailing winds at about this time has something to do with the matter.

In the Permanent Region locality matters but little so far as the continuation of the species is concerned, but outside of this the insect can continue but a few generations, and hence its great uneasiness and longing to get back to its native climes and home scenes.

While the true home of this locust is quite permanent in its leading characteristics, the Temporary Region is one of variable character and sudden changes, with unsettled winds. The surface of the Permanent Region is much the same throughout, while that of the Temporary Region is variable. The true difference between these two regions, however, which seems to tell on the life of *Caloptenus spretus*, is the amount of moisture present, and also the altitude. A wet or humid climate is unfavorable, while one that is arid is favorable to its increase.

The localities chosen by this insect for the depositing of eggs are such as are partly denuded of vegetation and where the soil is firm, as new breakings, pastures, roadsides, south hillsides and a variety of similar localities. Very low or wet grounds are never chosen, neither is very loose and sandy soil that is liable to be blown away by winds. The locust possesses similar habits throughout the country at times visited by it; yet these habits are necessarily slightly altered by variation of climate, surface configuration, and other influencing agencies. While in the Temporary Region the eggs are chiefly deposited in proximity to

fields, in the Permanent Region they are deposited throughout this region wherever there is sufficient grass for the young to live upon. The grasses, too, of these widely separated districts vary much in their nutritive properties. Those of the permanent home are the best in the eyes of this gastronome of an insect, and stand parallel with the various grains of the same localities during early spring. Our grasses on the contrary are not touched when wheat fields and other cultivated plants can be obtained. Even the weeds growing in fields are more acceptable than those on the prairie. When a swarm alights in this region for the purpose of depositing eggs it betakes itself to the foot-hills adjoining valleys where food is plentiful, or to the mountains just below timber. Here the locusts often accumulate in such vast numbers as to entirely cover the ground while at their work of perpetuating their kind. In speaking with a gentleman who spent the greater part of seven years in the northern and central portions of Wyoming, I was informed that during the summers of 1875 and 1876 at times these locusts were so numerous as to be piled up in windrows for miles in length and frequently six inches in depth. These were both old and young. They hatched on the foot-hills and ate the grasses clean. He said that "while the greater portion of this Permanent Region offers favorable situations for the deposition of their eggs, they are more partial to fertile valleys, sunny hillsides, and grassy plats near timber line where there is always plenty of succulent vegetation to be had." While the humid atmosphere of the Temporary Region is detrimental to its continued existence, the insect still requires a certain amount of moisture for its development in great numbers, hence it is that that large district, lying for the most part just below timber line on the extensive plateaus of the Northwest, is so well adapted to their increase. These sections, too, afford vast areas suitable for the deposition of their eggs, and afterwards for the development of the young.

Eggs are deposited at intervals during the months of June, July, August, September, and October, by insects maturing in different latitudes and at different times. The majority of them, however, are laid during the months of August and September; otherwise, if the fall should prove too warm and the winter late in commencing, many of them would hatch and die from cold and starvation.

Eggs laid in June often hatch by July and the locusts become fully developed in time to deposit before cold weather sets in too severely, while those hatching later very seldom deposit unless the fall is very favorable. Some eggs, too, very likely lie over one whole year before hatching.

Whether or not locust eggs would hatch after having laid more than a year, I am unable to say, as personally I have seen nothing of the kind, nor have I ever seen a substantiated account of any such occurrence in works on locust literature. It is, however, averred by several farmers living in the vicinity of Missoula, Montana, that in the fall of 1875 a great many eggs were deposited throughout the valley. Some

of these hatched the following spring (1876) and the locusts from them left without depositing; neither, it was believed, did any other swarms deposit this year. However this may have been, in the spring of 1877 large numbers of young locusts made their appearance among the foot-hills on the north side of Missoula River, where no eggs were known to have been deposited since the fall of 1875. Now, whether this was really a case of continued vitality of a large quantity of eggs during an entire year beyond the time when they should have hatched, as claimed by these gentlemen, or whether in 1876 a swarm might not, unobserved by them, have alighted in this locality, left their eggs, and then gone on, I will not try to decide, but will let every one draw his own inference. It would be interesting, however, to possess the facts with reference to this alleged case of continued vitality of locust eggs in a climate where under ordinary conditions they would have hatched in due time.

The time required for the hatching of the eggs varies greatly in different latitudes, at various altitudes, and at different times of the year. The presence or absence of warm or cool rains, too, seems to make a difference. Of course it is quite necessary that a certain degree of heat be present, as also a certain amount of moisture. Sometimes it appears that eggs will hatch in a comparatively short time, and at others, when there is no perceptible variation in the conditions, it requires much longer.

Just what amount of heat and what other conditions are absolutely necessary for the development of the eggs in the Temporary and Permanent Regions, or whether there is a difference in these, I cannot at present say, with the small amount of data at my command. But that there are certain things upon which the hatching depends can be readily inferred from the experiments that have been conducted by Professor C. V. Riley and others for this purpose. Nevertheless, they were insufficient to establish fixed rules by which we can go.

The young, after hatching, require from forty to sixty days in which to mature; varying, of course, according to the state of the weather, the abundance of food, and also their vigor; cold and wet retarding and warmth favoring their growth. Soon after hatching, the little fellows begin traveling in search of food, as they are generally hatched on grounds partially bare. They travel in droves, thus imitating in the start the peculiar traits of the species. These droves become scattered as from time to time they move on in their half famished search for food, and in the course of their growth become so scattered and mixed up that by the time of maturing hardly any two of a single brood are together. This is the case of swarms in the Temporary Region, and very likely is also true with reference to them in their native habitat.

Soon after leaving the eggs the little fellows molt or shed their skin, which operation is repeated four more times in most cases and at least three times in every case before arriving at maturity. The manner of molting is quite similar to the like act with other insects. The larva

quits feeding and becomes dejected and drowsy, creeps to some sheltered nook and there lingers for a time, when the skin of its head and thorax cracks and it wriggles itself out a soft and tender looking 'hopper. Soon, however, the tender limbs and body become dry and rigid, and the "new" locust is again in trim for its raids with thousands of comrades that have also just undergone a like transformation. Its skin is now loose and flabby, and its appetite keen from its late fast. The time required for this transformation or rather molting of the skin varies from one-half to more than one hour, according to the state of the weather and strength of the locust; warm, sunshiny mornings, immediately after a gentle shower, being the most favorable; at least this is my experience in reference to the last or pupal molt.

The habits of the young are quite similar to those of the mature insect in many respects, while in others they differ to some extent. As just mentioned they are migratory by nature and commence traveling soon after hatching, not entirely in search of food, but also for the purpose of satisfying that inherited longing for travel with which all little *C. spretus* come into the world. They all move in the same general direction in which their parent swarms did as they came into the district where the eggs were deposited. On warm sunshiny days the little fellows become somewhat scattered as they hop about in search of food; but on the approach of night or lowering weather they huddle together in sheltered localities, especially in old grass, straw piles, under clumps of dirt, &c., where they seem to be contented. As they grow older their numbers diminish from the loss of companions by birds, insects, disease, and the hardships of cold and wet; but their desire to move has also increased. They have left their hatching places and gone to the neighboring fields if in a settled district, or to the green valleys where tender herbs and grasses abound if in wild and unsettled districts. The pupal or intermediate stage differs but little from that of the larval save that in this stage of their lives they are more slovenly or sluggish and less ravenous, although not altogether dormant like the corresponding stage of some other insects.

During storms and cool days in spring the young are often so benumbed that they are unable to rally with the succeeding sunshine, and in such cases die of sheer exhaustion.

Having mentioned a few characteristics pertaining to the natural history of the young, it will now be in place to mention a few additional traits belonging to the old or winged insects.

As soon as circumstances will permit after the advent of its change from a wingless insect to that of one possessing wings, it leaps into the air, unfolds its new and hitherto untried members and takes a short flight. As soon as everything is favorable, which is on the first fine morning with a pretty brisk breeze, with one accord numbers spring into the air, and begin rising in a circling manner until they have attained a sufficient altitude, when they permit the wind to carry them

along. During flight their position is generally face to the wind and partially elevated. At least this is the position in which I have noticed great numbers of them while drifting. They do not fly, but float on the breeze, and move no faster than the wind does.

While on the move their actions are controlled to a great extent by the atmospheric conditions which have already been noticed under the head of "general notes." When hungry they come down and feed, and then are off again. This state of affairs continues until near the time for commencing operations for the continuation of their kind. This takes place within two or three weeks after obtaining wings. Coition and egg depositing are then kept up alternately until cold weather sets in or until they die of exhaustion; the number of egg deposits made by a single female varying from one to four, each of which averages 25 eggs; the interval between egg deposits being from four to eight or more days according to the state of the weather and the vigor of the insect, it being much more frequent in favorable weather and with healthy and vigorous females. After egg laying is over they die from the effects of frosts and from the exhaustion brought on by the exertions of reproduction.

"How does it happen that this insect becomes so exceedingly numerous at times when other species remain normal?" is a question that has frequently been submitted to me. My answer is, through its migratory habits and the character of its native habitat. As soon as surroundings become adverse to its increase, it has but to launch itself into the air and be off for a locality where these are favorable, and where there are few or no enemies; while species not possessing this habit are obliged to remain and struggle on in the best way they can. While migration does not always prove beneficial in this direction, the cases where it does not are so very few that in the end they are not noticeable.

If we take any insect that has gradually developed this habit we find one that has become alarmingly common and destructive. The Colorado Potato Beetle, for instance, is an example of this sort. But a very few years ago we only heard of it as being found in moderate numbers feeding on a wild species of solanum (*Solanum rostratum*)—a native of Colorado and adjacent country. On the approach of man, however, with his cultivated plants it found a new solanaceous plant that it preferred to its old and long-used one. The growth of the latter being certain and not fortuitous gave this insect a basis, and in a very few years it began to move from field to field, establishing colonies wherever it went, until now it has not only spread throughout all Eastern North America, but has also succeeded in reaching Europe. Although not a parallel case with that of *C. spretus*, it is a fair example of how migration favors the increase of a particular species of insect in contradistinction to one that is non-migratory. The Chinch Bug and Cotton Worm are also examples of the increase by migration or moving from one locality to another.

Of course, in the case of the locust, there are other agencies besides migration that tend to such abnormal and alarming increase. The peculiar climate and surface configuration of its native habitat are both of such a nature as to favor this end. The long stretches of treeless areas, and the comparative absence of enemies of all kinds, with the aridity of climate, are such as to favor it in the highest degree; also the absence of man's destructive agency. When the numbers become excessively great in their native habitat, their desire for moving increases to such an extent that they are not satisfied with short journeys—in fact they are obliged to take long ones in order to find the necessary amount of food which so great an army of ravenous locusts requires. It being impossible to obtain this short of a climate of such a nature as to produce an exuberant growth of vegetation, they necessarily continue to drift with the wind until such a region is reached. Since, during these movements, the prevailing winds are from the northwest and west, the swarms must accordingly reach the fertile regions along the Mississippi Valley, in Dakota, Minnesota, and southward. While here they must follow their instinct of continuing their kind, and accordingly deposit their eggs—always choosing such localities for this as most nearly resemble the arid region from which they came. These eggs hatch with favoring weather, and produce great numbers of young. Some of these as they mature rise into the air and are returned to the arid regions of the West and Northwest by winds prevailing at this time of the year; while others are destroyed by various animals, birds, and insects, and also by moisture and heat. To prevent these migrations and to destroy both old and young while with us in the Temporary Region, and also in the Permanent one, has been the aim of those who have taken sufficient interest in the matter to make it a subject of study. Just how nearly this object has been attained, I will not say; but that much has been accomplished there is no denying.

Aside from man, and the numerous contrivances which he has perfected with which to destroy this insect in all of its stages, there are hundreds of birds, mammals, reptiles, and insects, that spend the greater portion of their lives in keeping this locust within bounds, and which by their work alone would soon reduce its numbers to a normal condition, if they could only follow it up, or if it could be kept in one locality—this locality to be within the confines of the wooded portion of the Temporary Region.

It is not my intention now to enter into a detailed account of all of those that I have seen in the act of devouring this and other locusts. For such an account I am pleased to be able to refer all who desire to study this particular branch of locust literature to Prof. Samuel Aughey's admirable work, entitled "Nature of the food of Nebraska Birds," and published in the first report of the Commission. In this essay the author cites not less than 630 cases of dissection of at least 90 species of birds, made by himself during a period of twelve years. These dis-

sections show how partial almost every one of these birds is to locusts as food. Not only the wild birds of a country, but also all kinds of poultry attack them with avidity. Even squirrels, mice, chipmunks, weasels, skunks, and larger animals devour them in great numbers. During my sojourn in Central Montana last summer (1880), I frequently saw the little striped squirrels (of which the country is full) capturing and devouring locusts, and that this is a common practice with most rodents there is but little doubt, as we know their habit of frequently changing their diet from vegetable to animal substances, and also find numerous remains of locusts and other insects in the neighborhood of their haunts. All reptiles and fishes at times do a great deal towards lessening the numbers of this as well as other injurious insects. However great is the destruction of locusts by these animals, which we can see, it is carried on in a much larger scale by insect parasites which we do not notice. These are almost equally as numerous in species and far more so in individuals. Some of them confine their attacks exclusively to the eggs, others to the young, while still others only destroy the mature locust. Others attack it in all of its stages, and in their modes of life succeed in accompanying it throughout large tracts of country.

The eggs of the locust are attacked by a great variety of insects, which, as a rule, feed upon them in their larval stages. Of these the most noticeable are several species of two-winged flies of the genus Anthomyia, quite a number of species of what are popularly known as "bee-flies," and the grubs of several species of beetles that are closely allied to the "Spanish Fly." In addition to these quite a large number of other species have been known to attack them.

The most beneficial of these egg parasites are those known as locust mites. These often become very numerous, at times having been known to destroy as high as 70 per cent. of the eggs laid in portions of Minnesota. They have also done much good in portions of Dakota, Iowa, Nebraska, Kansas, and Missouri, and in part helped to save many a field of grain that would otherwise have been devoured. Native species of locusts are also attacked by these mites, but whether these are of the same or different species I am unable to state at present, not having examined them with a view of determining them. I have also seen several species of Meloidæ so completely covered by these little red mites that they appeared like a moving mass of red insects, and it was with great difficulty that they were enabled to move about.

The habits of these mites are such, too, as to aid in the furtherance of their good work. Early in the spring

The female lays between 300 and 400 minute, spherical, orange-red eggs in the ground. They are usually from one to two inches beneath the surface and in slightly agglutinated masses, which, however, easily become scattered upon disturbance of the soil. From these eggs, in due time, there hatch little orange mites, which differ from the parent in having but six legs.—(Riley.)

These minute mites are very active, and from hunger or by instinct soon crawl upon the bodies of locusts, where they fasten themselves to the wings and softer parts and fill themselves with the locust's juices. Being now aboard, when the locusts start out on their migrations, these unwelcome and dangerous passengers are carried by them to their new breeding grounds. As soon as the little fellows have sufficiently gorged themselves they let go their hold and drop to the ground, where they betake themselves to some sheltered place and continue to grow and change their form. By this time their adopted hosts have gone to work and deposited their eggs. They now, or early the following spring, crawl down through the mucous substance which fills the upper portion of the hole in which the eggs have been deposited until they reach the eggs, when they begin their good work by devouring them one after another.

The bird enemies of the locust's eggs are very numerous; and in many instances, without the aid of the farmer, they scratch out and devour great quantities of them. The principal mode, however, in which they work is to follow the plow and harrow and eat the eggs after they have been turned up and partially exposed to view. Blackbirds, crows, and many small birds, with poultry, are the most active in this work of destroying eggs. Mice and shrews, too, are very fond of locust eggs, and quite frequently have I seen where they have dug up and eaten them. In localities adjoining low, wet places instances of this kind are quite common, and in such localities I have on several occasions surprised and disturbed these small mammals while apparently at this good work.

The young or larvæ are equally and, if anything, more sought after and devoured by these various classes of enemies. Birds will live on them alone in preference to their ordinary food, while a great variety of beetles, flies, wasps, &c., will eat them ravenously. In fact so greedily are they sought for by these animals that it is really surprising that a single one of them attains maturity. It is due only to their great numbers and to their habit of secreting themselves.

Neither are the mature locusts free from the attacks of these various enemies, but, having increased so much in size, it requires fewer of them to satisfy the appetites of this reducing army. Nevertheless millions of these too have been permitted to mature only to be eaten ere they make provision for a future generation by depositing their eggs.

Among the internal parasites of the locust are various species of Tachina and flesh flies. These, at all times and in every part of both the Permanent and Temporary Regions, do much towards diminishing the otherwise large increase of this dreaded pest. As far as I am personally concerned, I must confess that I have never bred more than about a dozen of these flies from locusts. These were about equally divided between two species, viz., *Tachina anonyma* Riley, and *Sarcophaga carnaria* L. I have, however, seen hundreds of their maggots creeping

along the ground during locust years, and have also taken a very large number of the locusts that were infested with them. At present I cannot recall the dates when they appeared in greatest numbers, but recollect quite well their appearance in 1865, when I was assisting some neighbor boys to keep the locusts from a cabbage patch.

I do not now remember whether I obtained any of the flesh flies (Sarcophaga) from the bodies of the matured locust, but have taken them on the ground soon after they left their victims. Some of these flies infest the larvae and pupae as well as the winged insects. I have also often seen them attacking other species of locusts besides the migratory one, and not unfrequently have I found these grubs or maggots in my drying box after having pinned large series of "natives." These undoubtedly belonged to several species and genera, judging from their slight differences in size and form; but as I had not the time and facilities for rearing them, the species remain undetermined.

Until quite recently the larval habits of our various blister beetles were but little understood. Since the researches of the Commission, however, the preparatory stages of many insects which had hitherto been shrouded in mystery have been ascertained for the first time. Among these were those of quite a number of the *Meloidae*. It has been ascertained that they feed upon the eggs of locusts, and especially those of *C. spretus*. This, then, accounts for the great numbers of these insects that are found in all the leading locust areas of the West and Northwest, especially in the latter district. Riley has shown in the report for 1878 and 1879 the peculiar and interesting feature possessed by the young of some of these insects of protracting development one, two, or even more years, thereby supplying a new means for the continuation of a species that is dependent upon uncertainties for its continuuation among the living.

I have noticed a great number of species of these insects both in Montana and Colorado. In Montana they were mostly partial to the *Leguminosae*—*Lupinus*, *Astragalus*, &c.—some of which in certain localities were covered with these beetles and denuded of their foliage, thus furnishing an example of an insect that in its preparatory stages is parasitic on another, and that after maturing lives upon a plant not eaten by the insect on which it was a parasite. In this way, then, the parasitic beetle is not only insured a chance of perpetuating its kind through its capability of lying dormant in its imperfect stages for an indefinite time if the necessary amount of food is absent, but also through its choice of food, in its perfect state, since it lives upon that which the locust discards. In Colorado the food-plants of these beetles are chiefly such as belong to the *Compositae* and *Solanaceae*—a few choosing the cultivated potato.

To these natural remedies add all those which have been devised by man, and we have such a formidable array of destroying agencies at work against the lives of these locusts in the egg, larva, pupa, and winged states, that, were it not for their incalculable numbers, they would

soon be eradicated forever from the face of the earth and an end put to their ravages. But, taking into consideration the vast numbers of these insects in connection with their leading traits, we sometimes lose all faith in our ability to ever keep them within bounds. If we could prevent their migrations, perhaps we might hope for success; but otherwise not. This is the conclusion arrived at by those who have not devoted a lifetime to the study of this and other insects of like nature.

Those, however, who have looked into its minutest traits and followed the insect throughout the various portions of country at times visited by its swarms, even hope to be able at some future time to check its devastations notwithstanding its migratory nature and its habit of withdrawing from the settlements to the vast unsettled plateaus of the West and Northwest, where for a succession of years it goes on with its process of multiplying without being disturbed by birds and other natural enemies—in fact where everything appears to favor its greatest possible increase. They hope to be able to prevent its coming into the country known at present as its Temporary Region, or place of periodical visits. This can only be done by preventing its abnormal increase in its native habitat. Just how this will be accomplished, it is difficult at present to state; but by watching carefully and noting from time to time all the weak points in its habits that present themselves, I am confident that at some time in the future we shall learn the true secret of its strength, and thereby be enabled to head it off. In order to do this, however, we must be on the alert and continue to study it in its native habitat—gathering all the additional data possible in relation to its breeding, habits, movements, enemies, and the influence of various agencies upon all these. No other insect that has been studied with a view to its destruction has so long baffled the efforts of experts in their desire to discover some means of reducing its numbers as this one has; and this has been all owing to its general modes of life. There is hardly another one but that sooner or later has been compelled to succumb to man's devices.

Tree culture, too, throughout the country would be one step towards the final extermination of this insect. By planting groves of trees throughout the prairie lands, timber-loving birds would be enticed away from their haunts along rivers and smaller water-courses, and thus would millions of insects be destroyed that otherwise would propagate their kind in numbers sufficiently great to destroy everything green. As before intimated, the absence of trees from these vast stretches of the West is the principal reason for the development of locust swarms, and wherever we find a country of like character we find one that possesses its hordes of migratory locusts, and that at times sends out its swarms into the surrounding fertile districts.

Knowing that, as a rule, every animal, whether vertebrate or invertebrate, is so constructed as to be able to withstand only a certain amount of variation in climate and diet, the question naturally arises whether

or not the difference in climate and vegetation between the permanent and temporary home of this insect does not have some influence on its growth and increase, as well as on its adaptation to these diversities. The Permanent Region, with its comparative sameness of climate season after season and year after year, is in unison with this insect's mode of life. Hence, when it chances to come into a country that has a variable climate these influences begin to count against it. The region temporarily occupied by *C. spretus* is one in which there is much rainfall, and which is warmer than its permanent habitat. While the eggs do not appear to be deposited earlier in one section than in the other, the continuation of the warm weather of autumn in the Temporary Region has a tendency to partially hatch these, and the following cold winter weather to destroy their vitality. In other words, after the eggs have once begun hatching the alternate freezing and thawing or cessation of this process diminishes their vitality to some extent. Consequently, young hatched in this temporary locality are not as robust and healthy as those reared in the Permanent Region. A remarkable instance illustrating this was the spring of 1877 after the open winter previous. In speaking of this Professor Samuel Aughey says:

> It (the locust) cannot long endure a combination of low altitudes and moisture, combined with extreme and sudden changes of temperature. Hence, the locust can never become localized in Nebraska. The memorable spring of 1877 is a notable illustration of this fact. In March and April immense numbers hatched out, and then followed cold rains, with sudden alternations of extremes of temperature. Countless millions of young locusts died. In many spots where the ground seemed to be covered with them, none could be found in a few days. Nothing convinced me that death was the cause of their disappearance, until, getting down on my hands and knees and examining the ground with a huge magnifying glass, I found their dead carcasses. The young brood just hatched out disappeared as if by magic from whole counties. The localities where much damage was done were exceedingly few. In fact the brood was so impaired constitutionally that it fell an easy victim to the extremes of a moist climate in a comparatively low altitude. I also noticed, in previous locust years, that moisture accompanied by an extremely hot or cold day, was always fatal to many of them.

Numerous instances of like character came under my notice in that and other years.

The winged locusts, too, suffer from the effects of change of climate which they must undergo in passing from the Permanent to the Temporary Region. Quite a number of instances of internal fungoid growths have come under my notice within the past twelve years. I have also seen large numbers of them die from the effects of what to me appeared to be some kind of pestilence. When examined with a microscope nothing unusual could be detected except the peculiarly flabby and unhealthy appearance of their muscles and viscera, which were of a yellowish color.

Locusts' eggs are so much affected by the warm falls of this region that in the following spring they are found to be partially destroyed by semi-decomposition.—(Aughey.) Many of them also become attacked by

mold. I recall very well the spring of 1873, when great numbers of the eggs deposited the previous fall failed to hatch, and upon examination were found to be moldy. This is caused by the warm wet weather in fall. The lining and covering to the egg-pod partially decompose under these conditions, and then this decomposition is imparted to the eggs, which undergo a sort of fermentation—thus fitting them for the growth of various molds. This condition of affairs was quite extensive in this and adjoining counties[4] where I had the opportunity of examining them, but how general in the State I am unable to state, as I made no efforts at the time to ascertain. Sandy soil, however, appeared to be comparatively free from these conditions, I suppose on account of its porousness and property of absorbing moisture, or of permitting it to soak in. In those localities where the eggs were attacked by mold the species of Anthomyia flies were also quite numerous. Hence, it appears that on sandy soil the eggs are freest from all destructive agencies; true, such localities are more like the permanent breeding grounds.

Naturally with the increase in the number of farms and advance of the settlements upon the frontier the devastation by locusts will be felt less. They will divide their ravages among more farmers, and hence none will feel the losses nearly as much as did those who were isolated from their neighbors during past invasions. Thinly-settled districts suffered much more than those which were more thickly settled; and those lying out upon the prairie than those adjoining and interspersed with groves. During these invasions there was no year but in which a portion of the crops was saved and harvested by the farmers of the extreme eastern portion of Nebraska and other sections of country that were comparatively thickly settled, and that were situated near some natural timber-belt and interspersed with planted groves; while, on the contrary, those that were far away from these natural and artificial groves, and thinly settled, were entirely devastated by the hordes of ravenous insects. Hence we are compelled to acknowledge that the settling of a country in which the settlers are tree-planters has a tendency to diminish the ratio of locust injury.

Tree-planting is not only a matter of great importance to the inhabitants of a country like ours in supplying a much-needed material for fuel during our severe winters, when at times it is impossible to obtain coal—either from the failure of a sufficient supply at the mines, or from the impracticability of reaching towns where it can be obtained—but it is also of untold benefit as a moderator of climatic extremes. By planting trees throughout the Temporary Region wherever they will grow, in time the area in which the locust is capable of continuing its existence but two or, at most, three generations, without having recourse to the arid regions hitherto referred to as the permanent breeding-grounds, will be increased. Aside from the greater amount of humidity that would naturally follow tree-planting, the spread of

[4] Cuming County and others in Nebraska.

locust-feeding birds would be correspondingly increased, and the amount of good thus accomplished could hardly be estimated. As long, however, as there are no retreats or building places in which these little feathered friends of ours can rear their little ones, we need not look for their aid in fighting insect enemies.

The increase in the number of settlers would also add to the number of individuals to fight the locusts, and hence help to increase the sum total of their dead and to diminish the swarms otherwise remaining to do damage and to increase at the ratio of an hundred-fold.

There has been a great deal of disagreement in reference to the continuation of the flights of locust swarms during short and local rainstorms, and also at night. That they do continue I think there can be no longer any doubt, since the cases where locusts were seen in the air immediately before and after local rains of short duration are quite common. This summer, while near Golden, Colo., I saw a few locusts flying very high during the progress of a rain-storm. I was at an elevation of about 8,500 feet at the time, and the locusts were seen through small openings in the clouds. At other times also, of which I cannot just now give the precise dates, I know of instances where thunder showers came up, and during their progress large numbers of locusts came down as if with the rain. The first of these, of which I have any knowledge, occurred in the month of August about fifteen years ago. About noon, or a little later, a heavy thunder shower came up from the northwest, and we boys, who were out with the cattle, began gathering them together so that we could remain in the shelter of a tent that we had erected during the coming of the shower. Well, just how we succeeded I do not now remember; but after it had rained about an hour we went out, when, to our great surprise, there were thousands of "grasshoppers" jumping about in every direction, and others were coming down as if from the clouds. The majority had fallen during the earlier part of the storm, however, as we noticed comparatively few of them coming down. During the same afternoon, after the sun came out, others were seen in the air. Those which had fallen did not leave until the next day. A few of them must have been killed in coming down, because every now and then we found their carcasses lying on the ground, some of which we picked up and used on our pin-hooks for catching fishes. Other incidents, similar to this, have occurred since, but as they did not impress themselves as vividly upon my mind as did this, I do not now recollect them as well, and therefore can give no date.

Also during nights when the wind continues to blow quite briskly, and the temperature remains unchanged or falls but little, swarms that are on the move sometimes continue to fly. I recollect several instances in proof of this where locusts were known to leave a certain locality about noon one day, and were not known to have come down until some time during the following day. One of these occurred in

1873, when a swarm left the southern part of the State, and did not alight again until the following day, when it came down in the northern part of the State, having flown about two hundred miles before coming down to feed. Other small swarms have frequently come during the night and eaten fields of grain before morning. A case of this kind occurred in 1865, near Fort Calhoun, Nebr. In the evening no 'hoppers were to be seen, but on the dawn of the following day they had appeared and eaten the greater part of a field of corn.

The majority of cases where swarms have been known to continue their flights into the night are confined to the Temporary Region, and during the earlier part of the year when they are working their way northward with south winds. The further north they proceed, and the closer to the Permanent Region, the fewer are these unnatural flights. This is undoubtedly due to the comparative coolness of the atmosphere in these high latitudes and great altitudes, which anyone knows is a restriction to their activity. Moonlight nights, too, are preferred for these journeys in preference to dark and cloudy ones.

Although the general rule is for this insect to be single-brooded, it does occasionally by its position and migrations succeed in becoming double-brooded. Swarms reared in Texas in early spring sometimes reach Nebraska and even Southern Dakota in early May. These generally leave eggs that hatch in about a month, thereby giving the young the months of July and August in which to mature. These, however, it is claimed, never amount to much, on account of the abnormal conditions under which they are developed, and very rarely deposit eggs.

In the mountain district of Montana and Idaho, as well as in portions of the Temporary Region, I have noticed that after the majority of the young were full-grown there were still others apparently just hatched. Now, it may be that some of the instances of so-called double-broodedness in this insect, if critically examined, would prove to be the hatching of eggs that through various causes had been retarded longer than usual. That this unevenness in hatching is of frequent if not regular occurrence, anyone who has taken the least pains to ascertain will know; but however common this may be, there are and have been occasionally instances in which the evidence favoring double-broodedness could not well be doubted. We may then take it for granted that under certain conditions it is not only possible but actually true that *C. spretus* becomes double-brooded. Yet cases of this kind are comparatively few.

SUB-PERMANENT REGION.

Immediately joining the Permanent Region of this locust, and lying between it and the regions temporarily visited, is a tract of country possessing in part the characteristics of both of these regions. This section of country, as would naturally be supposed, is oftener visited by swarms of locusts from the north and west than are the various portions

of the Temporary Region, since it is much more favorably situated. This region, too, possesses the chief characteristics of the Permanent Region, but slightly modified, and hence answers as a sort of "stepping stone" in the passage of swarms from one region to the other. Here it is that quite frequently great numbers stop to breed in their flights from the northwest towards the settlements of Minnesota, Nebraska, and other portions of these Temporary Regions. Here they make provision for a fresh start the following season—not the same locusts, but their offspring. On their return flights also this intermediate location is used by the stragglers and those that come from the far south as breeding grounds.

This region is confined to the eastern rather than to the western range of the migratory locust—unless we also term the entire western breeding grounds, the Western Temporary Region. This, however, we would hardly dare to do, since in these parts it is enabled to continue year after year for an indefinite length of time without showing the least signs of disease and of dwindling. This interior basin and western mountain region being at a greater elevation than the region lying to the east, to which has been given the name of the Sub-permanent Region, more closely resembles the true home or Permanent Region, and hence its not being included under that name.

Having already noticed the partiality this insect possesses for a cool climate, we would naturally and truly suppose that it would be boreal in its nature. This being the case, we would expect to find it the most numerous and enjoying the greatest immunity from all sorts of deteriorating influences to the northward. This, at least, is the fact. The further north we go in the interior basin of the Mississippi and Missouri Rivers, the more at home do we find the locust. At present, however, it is not possible to give the exact temperature and other agencies that are requisite for this insect's greatest increase.

While this insect appears to be the only species that increases so rapidly and becomes very numerous east of the Rocky Mountains, there are several other closely allied species, or rather varieties, that at times become quite numerous west of this range of mountains. These undoubtedly are but local forms of *C. spretus*, produced by climatic and other influences. Of these other locusts, one in particular at times becomes very numerous, and moves in swarms precisely like those of the true or migratory species, *C. spretus*, and possesses habits almost identical with those of that locust. This is the *C. atlanis* Riley, treated of in the first Report of the Commission. It is confined to a locality having the peculiar climatic conditions of the Permanent Region, somewhat modified by the presence of a greater amount of moisture and an increase of temperature, also an increase in the timbered area. This region is confined to the mountain districts of eastern Oregon, and a portion of northern Nevada, with, perhaps, a small area in southwestern Idaho. This insect frequently drifts north into Washington Ter-

ritory, and thence eastward through Idaho into portions of western Montana, where it commits depredations on crops, like the true *spretus*, from which it is not considered distinct by the inhabitants. They think it has been stunted during growth.

A few words here as to the movements of locusts in these parts of the West may not be amiss. All those swarms that come into this western region from the north and east are composed of the genuine *C. spretus*, while those that leave approach nearer to *atlanis*. The movements here also differ to some extent from those east of the range, where there are long stretches of plains uninterrupted by mountain ranges and belts of timber as they are in the mountainous district west. Every river valley and mountain chain or spur has a tendency to change the course or to retard the movements of swarms, while the winds for the greater portion of the year are contrary, thus adding to the already numerous perplexities. To understand all these movements, and the laws by which they are regulated, will require considerable more time in which to investigate.

Other marked varieties of this insect are claimed by different farmers to occur in isolated sections of the Northwest, and it is thought these differences are altogether due to the variations in the climate and surroundings. For my part, I will not express an opinion at present, as I have not had sufficient opportunity to examine into the matter.

Although in the field from the middle of July to the 1st of November, I saw comparatively few of these locusts. Nevertheless at almost every locality where I stopped off, a few of them were seen.

While out on the plains east of Greeley, Colo., August 6, I saw a few flying to the north. They were the most numerous at about 2 o'clock a. m., but not numerous enough to cause unnecessary alarm. After this I saw other very limited flights in the vicinity of Fort Collins, Golden, and Denver. Others were seen on the ground with the "natives," but nowhere did I find them as numerous as several species of these latter. A "swarm" of locusts was seen on Salt River, a branch of the Snake River, about the last of July, by W. A. Irwin, of Rawlins, Wyo. He did not, however, notice any of them in the air, but was quite positive as to their identity. "Could not have mistaken them, as had seen too many in Kansas." Another swarm of this locust was reported as having hatched in the vicinity of Deer Lodge, Mont., the present year. "All at once" they disappeared and were thought to have been destroyed by birds and insect enemies, as none were seen in the air. Still another swarm was hatched among the foot-hills about Missoula, Mont., where they did some injury to wild grasses. They did not come down into the valley, but upon "getting their wings became very restless and flew about as if not knowing which direction to take."—(Dukes.) They finally left, mostly towards the south, a few, however, going north. Those going south followed up the Bitter Root and its tributaries, while those going north drifted towards the Flat Head Lake. Other swarms of locusts were seen at various localities on the Spokane and Snake River

Plateaus, where they hatched last spring. One of these in particular was quite extensive, though not known to have committed any injuries to crops as far as I was able to learn. This swarm was hatched along the line of the Northern Pacific Railway and westward, where they ate off the grasses in many localities. I was unable to ascertain anything definite about their movements, if any. Some individuals told me that they did not leave, but died off towards fall, while others said they had not noticed. Was not able to obtain any of the live insects, but gathered a few of their carcasses that were lying about on the ground. Another section where they were reported to have hatched this season in eastern Washington Territory is between Colfax and Dayton, where, at one place, they did much injury to several fields of grain. Others were reported as having hatched in the vicinity of Lewiston, and farther up the Snake River, as well as in a small portion of eastern Oregon. Very few, however, were noticed in the air.

It therefore appears that at present the number of these insects within the limits of the United States is comparatively small, and, if there are no more in the British Possessions to the north, we need not be alarmed the coming year, as there will be no probability of invading swarms.

The question now naturally arises whether or not we shall be visited in the near future by swarms of these locusts; and, if so, how can we ever expect to become rid of them. In answer to the former question I will say that this depends altogether on the number of locusts in the Permanent Region of Montana and northward from time to time; and also upon the seasons in these regions, as well as upon the prevailing winds while the locusts are upon the move. If there are but few locusts in this region we can receive but few from it. Again, as long as their numbers are few in any locality, their flights are correspondingly shorter. Should there, however, be a succession of favorable seasons in this region, we may expect them to call in the Temporary Region just as they have done in the past. Of course Dakota and Minnesota will be more in danger than those States lying farther southward, for reasons heretofore mentioned, and therefore the inhabitants of this section will always have more to do in fighting them than will those who live farther from their breeding grounds. However this may be, they are favored to some extent in the crops they raise, viz., wheat, oats, rye, and barley. Should the locusts come into our section of country, which is quite probable, the only thing for us to do is to take matters coolly and philosophically, and do all in our power to prevent their offspring from returning to the Permanent Region the following season; and not do as many farmers did during past invasions, viz., "put our hands in our trousers-pockets and expect the Commission to destroy the locusts, and the government to clothe us and our families until Providence gives us another crop. There is no longer any excuse for not knowing how to fight this insect in all its stages, since almost every county paper in districts visited or liable to be visited has hinted at the various means suggested

by members of the Commission and such energetic farmers as tried to save what they could of their crops.

Remember, also, that every effort put forth in fighting locusts is so much towards their diminution and future immunity from their attacks. Every locust that is destroyed before the breeding season subtracts about forty from the possible increase the following season.

In speaking of the future in reference to the depredations by locusts in Nebraska, Professor S. Aughey says:

> When the area under cultivation is trebled, the amount of damage which they can do will be more than one-half less. Another more potent agency against their increase and destructiveness is the increasing rainfall of the State. We have already seen how the wet season of 1877 destroyed the greater part of those that appeared that spring. During each coming decade the number of similar seasons will increase. The instincts of the locust will also prompt it to remain away from a region so hostile to its existence.[5]

What is true of Nebraska is also true, to a great extent, of the larger part of the Temporary Region.

For my part, I am inclined to believe that we have experienced the worst raids from this insect, and that if any more visitations are made in the future, each successive one will be felt less for reasons heretofore mentioned.

THE GENERAL OUTLOOK.

Having devoted so much space to the natural history and habits of this locust, it would be well to devote a little space to the probabilities of locust visits for 1882, and if any should appear, their extent and probable whereabouts. This can only be approximately stated by using the data of 1881 as a basis. As this insect covered but a comparatively small area in the Permanent Region within the United States, and in regions, too, so widely scattered, we may predict that its depredations will not be great the coming summer.

While there were a few small flights noticed east of the main divide of the Rocky Mountains, the majority of them were confined to the western portion of the locust area, heretofore noticed as the central region or that of the Snake River Valley. A few small swarms were reared at various localities in western Montana, northern Idaho, eastern Washington Territory and Oregon, as well as in Nevada and parts of Utah. These, although I was unable to obtain sufficient data by which to substantiate this supposition, after flying away from the localities in which they were reared, came down and deposited their eggs, which, of course, will hatch when the proper time arrives. These, according to custom, will migrate, but in most instances in numbers insufficient to commit great depredations.

The first locusts that I noticed or heard of this season were those noticed about two o'clock in the afternoon on the 6th day of August. They were on the wing at the time and were flying northward on a stiff

[5] Sketches of the Physical Geography and Geology of Nebraska, Omaha—1880.

breeze. This was in the vicinity of Greeley, Colo. I do not know where they were hatched, but think they had not come from any great distance. They were undoubtedly reared among the foot-hills west of Denver, and migrated to some part of Western Nebraska or South-western Dakota near the Black Hills. There were not enough of them, however, to cause alarm for the coming summer, but there may and in all probability will be a few scattered swarms emanating from these that may visit portions of Nebraska and Dakota. Again, on the 17th of August, a few *C. spretus* were noticed in the air and others on the ground, some of the latter of which were copulating preparatory to egg depositing. These, however, were few in number, and consequently of no importance.

The next swarm of locusts heard of was at Rawlins Station, where Mr. W. A. Irwin informed me that a swarm of locusts had been seen on Salt River, a branch of Snake River, in Eastern Idaho, July 30. He did not notice any of them in the air, but was quite positive that they were of the "migratory species," as he had seen this insect in Kansas and Nebraska when they were so numerous there.

Another swarm of locusts for this year was that hatched in the vicinity of Deer Lodge, Mont. Early in May the young larvæ appeared in great numbers over a small tract of country lying to the west of this city, where they did some damage to grass and several fields of grain in some of the smaller side valleys. They were supposed to have originated from a swarm that must have come in, left its eggs, and withdrawn immediately after this operation, as no one could inform me of the particulars, or even of any having been seen the previous fall. These also disappeared as mysteriously as they came, as none were seen to fly. It is my opinion now that this was the offspring of the small swarm that last season was reared a few miles southeast of Helena, and that was supposed to have been destroyed by a flock of sickle-billed curlew.

Another swarm, or rather several small swarms of locusts, were reared in the vicinity of Missoula and Frenchtown this past spring from eggs that were left by a swarm coming from the north and west. These did some damage to the wild grasses up among the foot-hills, but did not come down into the valley. As soon as they matured they became very restless and flew about in various directions, coming and going as if undecided what direction to take. They finally left, most going southward; but a few went to the north in the direction of Flat Head Lake and Boundary Pass, where they undoubtedly crossed over the range and entered the great Breeding Center of the North. Those going south I was unable to trace, but suppose they came to a halt somewhere in the Salmon River country, in which locality they will rear their young, to continue their southward movements the coming year.

During the fall of 1880 locusts came into the valleys of eastern Washington Territory from the northeast, did some damage to grain in some isolated localities along the line of the Northern Pacific Railroad,

and passed on southward, leaving eggs at various points along their line of march. One swarm seen this year (1880) on Haugman's Creek, about 48 miles south of Spokane Falls, was of considerable extent and continued for two days. It was about 4 miles in width where they flew thickest. After going as far south as the Palouse River they began depositing eggs and continued to do so until they crossed Snake River, after which they seem to have been lost sight of. Very likely it will prove to be identical with the swarm that was reported to have appeared and to have done damage to grain in the vicinity of Walla Walla during August of this year, 1880.

From the above-mentioned swarms originated numerous small ones, that were observed throughout various portions of this Territory during the present summer, 1881. These, however, were nowhere excessively numerous, and did but little damage as far as could be ascertained, save in a few isolated spots. Only on one occasion were any noticed in the air that I could learn of, and this information was so vague that I did not ascertain the direction in which they were moving. At Sprague, on the line of the Northern Pacific Railroad, great numbers of young were hatched, and also for some distance southward. These, however, do not appear to have migrated, but remained and deposited their eggs, since, on October 15, I found great numbers of their dead bodies lying scattered over the ground. I was informed that this particular locality is always more or less infested with this insect.

At several other points, especially along Snake River towards Lewiston, I was informed that young locusts had hatched and done some damage, but could not learn to what extent this occurred, nor could I ascertain anything in reference to their movements after maturing. At the crossing (Palouse Ferry) of Snake River in early spring, May, I believe, several fields of grain were destroyed by these little locusts. So it is impossible for me to predict anything in reference to locust probabilities in this portion of the country for the coming season, not knowing anything more definite in reference to the movements of the locusts hatched here this season.

In the fall of 1880 great numbers of eggs were deposited in portions of Nevada and Western Utah, which undoubtedly gave birth to some young locusts in the spring of 1881, but not having any data whatever from this portion of the West with which to substantiate this, I can give no further clew.

However free from locusts the country was in 1879, after the great raids of 1875–'77, they are again on the increase, and should be guarded against on all sides. Of course, there must have been many more of these small swarms in portions of the regions not visited by me, which, if nothing occurs to check them, in a few years will materially increase their numbers. Of course, at present, the movements of these swarms are all independent of one another, but as they become larger and more numerous they will be more closely connected, and finally become animated with one movement.

CHAPTER IV.

NOTES ON OTHER LOCUSTS, AND ON THE WESTERN CRICKET.[6]

In addition to the several species of locusts already noticed in this report, there are at least upwards of two hundred and seventy others that are known to inhabit the various portions of North America north of Mexico, and which are more or less injurious to the agriculturist and to those who are in any way dependent upon the products of the soil for their living. True, but few of these various locusts ever become so excessively numerous as do those concerning the history and habits of which I have just written; neither do they ever, except on rare occasions and with a few species, become imbued with a desire to migrate.

In their distribution these insects vary much. Some of them enjoy a very wide range, and are well represented both in climatic varieties and numbers; others are less widely scattered and are few in numbers, while still others are local in their haunts and quite few in individuals. Others again, while local, are well represented in numbers in their immediate localities. So diverse are the habits of these various species of "grasshoppers" that almost every nook embraced within this entire tract of country, where insect life is possible, possesses its one or two or even more representatives of this group of jumping insects. Even the cold and almost frigid mountain summits, as well as the parched and desolate desert regions of Arizona and New Mexico, furnish suitable haunts for a few hardy species that are so constructed as to be able to withstand these extremes of climate. However numerous these insects and diverse their haunts, it is nevertheless an undeniable fact that the greater number by far are partial to a country, the climate of which is moderately temperate and where the humidity is not excessive. Nebraska alone possesses at least 140 of them.

In the distribution of these insects we have noticed that the following rules can be relied on to a great extent: *Œdipoda* and allies are more partial to warm, sunny slopes where the ground is partially bare and where they have a chance to flit about in the warm, open air and sun themselves. *Caloptenus* and allies, as *Pezotettix*, *Brachystola*, &c., are more partial to low and cooler localities where they can rest in the shade and hop about among the more luxuriant and tender vegetation. *Acridium* is a lover of dense shrubbery and other luxuriant growths of vege-

[6]Continuation of Mr Bruner's report of observations under direction of Professor Riley, for 1881.

tation, while a few others frequent forests and their borders, where they revel in luxury from day to day with the katydids and other shade-loving insects. *Pezotettix*, with but few exceptions, prefers cool and shady localities, and hence is often found among or near rocks, on mountain slopes, in clearings or on the outskirts of timber belts, and in meadows. A few species, as *Chrysochraon* and *Stenobothrus*, are lovers of the cool and damp localities along streams, and as a rule either winter as larvæ or pupæ. These are often seen quite early in spring, and very frequently have been the cause of unnecessary alarm among the more ignorant persons, who imagined them to be forerunners of a general locust invasion.

However numerous these different varieties of locusts that are scattered throughout the various portions of the United States and northward, all the others combined do not cause one-tenth so much injury as *C. spretus* does. True, several others at times have been known to become quite numerous, and have committed much injury to crops and vegetation in general. The chief of these are *Camnula atrox*, *Caloptenus differentialis*, *C. femur-rubrum*, and *C. atlanis;* and at such times they have all exhibited to a greater or less degree the migratory nature of the *true* plague of the West and Northwest.

In addition to the above-named insects of this order, I have noticed the following locusts when their movements partook of the migratory character, viz: *Acridium americanum*, *Œdipoda plattei*, *Œ. longipennis*, and *Tropidolophus formosus ;* the male only of the last exhibiting this characteristic. They would start up without any seeming disturbance and fly great distances before alighting, and then repeat the action several times, invariably going with the wind. These movements were made independently of one another, though occasionally I have noticed several locusts in the air at the same time. Whether or not this was a case of true migration on the part of these insects I will not now stop to inquire; but confess that it not only looked so to me at the time, but also answered every purpose that such a movement could.

These "natives," as they are termed in contradistinction to the migratory species, deposit their eggs in such localities as agree with the habits of the different species. They are, however, generally partial to sheltered and partly bare grounds where the soil is firm and not too wet.

The young live where their parents do, and differ but little in their habits. They molt from three to four times.

Most, if not all, of these locusts are continually harassed by insect and other enemies. These enemies and parasites do not materially differ from those affecting *C. spretus*, and therefore require no additional description here.

The following is a list of the locusts, or "grasshoppers," as they are more commonly termed, inhabiting the United States and the adjoining portions of British America and Canada, as nearly as I can give it at

present with the very limited amount of current literature upon this subject at my command. It may, however, be complete enough to enable one to make an approximate estimate of the great numbers of locusts inhabiting our country:

NORTH AMERICAN ACRIDIDÆ NORTH OF MEXICO.

1. *Achurum brevipenne* Thomas.—Florida.
2. *Mesops wyomingensis* Thomas.—Wyoming.
3. *chlorizans* Thomas.—Florida.
4. *Mermiria alacris* Scudd.—Georgia.
5. *neomexicana* Thomas.—Colorado, Nebraska, &c.
6. *bivittata* Scudd.—Eastern and Middle United States.
7. *Opomala carinata* Thomas.—Eastern United States.
8. *aptera* Scudd.—Pennsylvania.
9. *brachyptera* Scudd.—Massachusetts, Wyoming.
10. *Leptysma marginicolle* Stål.—Florida.
11. *Aptenopodes sphenaroides* Scudd.—Florida.
12. *rufovittata* Scudd.—Florida.
13. *aptera* Scudd.—Florida.
14. *Pyrgomorpha brevicornis* Walker.—Southern United States.
15. *punctipennis* Thomas.—Tennessee.
16. *Oxycoryphus obscurus* Thomas.—Wyoming.
17. *Chrysochraon conspersum* Thomas.—Eastern States, British America.
18. *punctulatum* Thomas.—Connecticut.
19. *abdominale* Thomas.—Montana.
20. *obscurum* Scudd.—Florida.
21. *decorum* Scudd.—Colorado.
22. *Acrolophitus hirtipes* Thomas.—Colorado.
23. *Pediocertetes nevadensis* Thomas.—Nevada.
24. *Stenobothrus occipitalis* Thomas.—Colorado, Wyoming, Idaho.
25. *coloradus* Thomas.—Colorado, Wyoming.
26. *tricarinatus* Thomas.—Wyoming.
27. *admirabilis* Uhler.—United States east of Rocky Mountains.
28. *subconspersus* Walker.—Florida.
29. *speciosus* Scudd.—Minnesota.
30. *maculipennis* Scudd.—Florida, Massachusetts, Wyoming, Minnesota, Nebraska, &c.
31. *æqualis* Scudd.—Massachusetts, Maine, New York, Minnesota, &c.
32. *bilineatus* Scudd.—Massachusetts.
33. *propinquans* Scudd.—Utah, Nebraska, &c.
34. *curtipennis* Scudd.—Nebraska, North America east of Rocky Mountains.
35. *clavatus* Thomas.—Kansas.

36. *Stenobothrus occidentalis* Sauss.—Tennessee.
37. *brunneus* Thomas.—Colorado, Wyoming.
38. *quadrimaculatus* Thomas.—Colorado, Wyoming.
39. *gracilis* Scudd.—Nebraska.
40. *pelidnus* Thomas.—Pennsylvania.
41. *Gomphocerus simplex* Scudd.—Delaware.
42. *virgatus* Scudd.—Texas.
43. *shastanus* Scudd.—California.
44. *clepsydra* Scudd.—Colorado.
45. *navicula* Scudd.—Colorado.
46. *clavatus* Thomas.—Kansas, Nebraska, &c.
47. *euterpe* G. M. Dodge.—Nebraska.
48. *Stetheophyma lineatum* Scudd.—Massachusetts.
49. *gracile* Scudd.—Maine, British America.
50. *platypterum* Scudd.—New England States.
51. *Chimarocephala pacifica* Scudd.—California.
52. *brevipennis* Scudd.—California.
53. *viridifasciata* (De Geer) Scudd.—United States.
54. *obiona* Thomas.—Colorado.
55. *infuscata* Harris.—United States east of Rocky Mountains.
56. *Psoloessa texana* Scudd.—Texas.
57. *ferruginea* Scudd.—Texas.
58. *maculipennis* Scudd.—Texas, Colorado.
59. *Arphia simplex* Scudd.—Texas.
60. *conspersa* Scudd.—Texas.
61. *luteola* Scudd.—Texas.
62. *frigida* Scudd.—Montana.
63. *arcta* Scudd.—Colorado.
64. *teporata* Scudd.—Colorado, New Mexico.
65. *Tomonotus sulphureus* Sauss.—United States, Vancouver's Island.
66. *xanthopterus* Thomas.—Eastern United States.
67. *carinatus* Thomas.—Iowa, Missouri, &c.
68. *tenebrosus* Thomas.—Central United States.
69. *zimmermannii* Sauss.—Florida.
70. *Stauronotus elliottii* Thomas.—Colorado, Wyoming, Montana.
71. *Tropidolophus formosus* Thomas.—Colorado, Wyoming.
72. *Spharagemon æquale* Scudd.—North America east of Rocky Mountains.
73. *bolli* Scudd.—Texas.
74. *balteatum* Scudd.—Eastern United States.
75. *wyominganum* Scudd.—Wyoming.
76. *collare* Scudd.—Central United States.
77. *cristatum* Scudd.—Texas.
78. *Encoptolophus sordidus* Scudd.—United States—eastward.
79. *costalis* Scudd.—Texas.

80. *Encoptolophus parvus* Scudd.—Texas.
81. *Circotettix carlingianus* Thomas.—Nevada, Montana, and British America.
82. *maculatus* Scudd.—California.
83. *undulatus* Thomas.—Colorado.
84. *Trimerotropis latifasciata* Scudd.—Washington Territory.
85. *fontana* Thomas.—Utah.
86. *similis* Scudd.—Washington Territory.
87. *cæruleipes* Scudd.—Oregon.
88. *vinculata* Scudd.—Washington Territory.
89. *verruculata* Scudd.—Illinois, Nebraska, Montana, and Dakota.
90. *suffusa* Scudd.—California, Utah.
91. *citrina* Scudd.—Colorado.
92. *obscura* Scudd.—New Mexico.
93. *pseudofasciata* Scudd.—California.
94. *juliana* Scudd.—California.
95. *picta* Scudd.—Florida, Georgia.
96. *Dissosteria carolina* Scudd.—United States, Canada.
97. *longipennis* Scudd.—Kansas, New Mexico.
98. *nebrascensis* Bruner.—Nebraska.
99. *Hippiscus corallipes* Scudd.—Utah, Nebraska, Dakota, &c.
100. *lineatus* Scudd.—Idaho, Colorado.
101. *neglectus* Thomas.—Colorado, New Mexico, Wyoming.
102. *haldemannii* Scudd.—Colorado.
103. *putnami* Thomas.—Utah or New Mexico.
104. *discoideus* Stål.—Florida.
105. *Camnula atrox* Scudd.—California, Oregon, Nevada, British America, &c.
106. *pellucida* Scudd.—Maine, Massachusetts, &c.
107. *Aulocara decens* Scudd.—Utah.
108. *cæruleipes* Scudd.—Colorado.
109. *Psinidia wallula* Scudd.—Washington Territory.
110. *eucerata* Harris.—Florida.
111. *sulcifrons* Scudd.—California.
112. *Œdocara strangulatum* Scudd.—Colorado.
113. *Stirapleura decussata* Scudd.—Colorado, Montana.
114. *Phlybostroma parvum* Scudd.—New Mexico.
115. *pictum* Scudd.—Nebraska.
116. *Hadrotettix trifasciatus* Scudd.—Colorado, Wyoming, Dakota, Montana, Nebraska, &c.
117. *Trachyrachys aspera* Scudd.—New Mexico.
118. *coronata* Scudd.—New Mexico.
119. *Derotmema cupidineum* Scudd.—New Mexico.
120. *Aconia integra* Scudd.—California.
121. *Œdipoda venusta* Stål.—California.
122. *marmorata* Uhler.—Massachusetts.

123. *Œdipoda haydenii* Thomas.—Colorado, Wyoming.
124. *fenestralis* Uhler.—Florida; North America.
125. *gracilis* Thomas.—Colorado, Wyoming.
126. *kiowa* Thomas.—Colorado, Nebraska, Dakota, &c.
127. *cincta* Thomas.—Colorado, Wyoming, Illinois, &c.
128. *plattei* Thomas.—Colorado, Wyoming, Nebraska, &c.
129. *maritima* Uhler.—Massachusetts, Connecticut.
130. *hoffmannii* Thomas.—New Mexico and Arizona.
131. *montana* Thomas.—Montana, Idaho, &c.
132. *paradoxa* Thomas.—Utah, Idaho.
133. *rugosa* Scudd.—United States, Vancouver's Island.
134. *phœnicoptera* Germ.—United States.
135. *parviceps* Walker.—California, &c.
136. *Chlöealtis viridis* Scudd.—Florida, Nebraska, Connecticut, Illinois, &c.
137. *brunneus* Scudd.—Texas.
138. *Amblytropidia subhyalina* Scudd.—Texas.
139. *Dociostaurus ornatus* Scudd.—New Mexico.
140. *Leprus ingens* Scudd.—California.
141. *Scyllina delicatula* Scudd.—Colorado.
142. *Boöpedon nubilum* Thomas.—Nebraska.
143. *flavofasciatum* Thomas.—Nebraska, Colorado, Wyoming, Montana, &c.
144. *Phrynotettix verruculatus* (Uhler MSS).—Pecos River, Texas.
145. *Platyphyma montanum* Thomas.—Montana.
146. *Chromacris colorata* Walk.—South Carolina.
147. *Tropidacris dux* Scudd.—Texas.
148. *Brachystola magna* Scudd.—Colorado, Kansas, Wyoming, and Nebraska.
149. *virescens* Scudd.—Texas, New Mexico.
150. *Eremobia magna* Thos.—Arizona.
151. *Acridium frontale* Thomas.—Kansas.
152. *unilineatum* Walker.—Indiana.
153. *rubiginosum* Harris.—Eastern United States.
154. *alutaceum* Harris.—Eastern United States.
155. *emarginatum* Uhler.—Colorado, Nebraska, and Dakota.
156. *americanum* Scudd.—Eastern and Middle United States.
157. *ambiguum* Thomas.—Illinois, Kansas, and Tennessee.
158. *obscurum* Burm.—Southern States.
159. *shoshone* Thomas.—Arizona, Nevada, Utah.
160. *vagum* Scudd.—California.
161. *appendiculatum* Uhler.—Florida.
162. *Dictyophorus reticulatus* Thunb.—Florida.
163. *marci* Burm.—Florida.
164. *Pezotettix olivaceus* Scudd.—Texas.
165. *acutipennis* Scudd.—Texas.

166. *Pezotettix variegatus* Scudd.—Colorado, New Mexico, &c.
167. *dumicollis* Scudd.—Texas.
168. *nudus* Scudd.—Texas.
169. *lakinus* Scudd.—Kansas, Colorado.
170. *texanus* Scudd.—Texas.
171. *discolor* Scudd.—Texas.
172. *flabellatus* Scudd.—Texas.
173. *pupæformis* Scudd.—Texas.
174. *aridus* Scudd.—Arizona.
175. *aspirans* Scudd.—Colorado.
176. *rotundipennis* Scudd.—Florida.
177. *puer* Scudd.—Florida.
178. *dodgei* Thomas.—Utah, Montana, Colorado.
179. *tellustris* Scudd.—New Mexico.
180. *marshallii* Thos.—New Mexico, Colorado.
181. *stupefactus* Scudd.—New Mexico.
182. *plagosus* Scudd.—New Mexico.
183. *marginatus* Scudd.—California.
184. *vivax* Scudd.—New Mexico.
185. *jucundus* Scudd.—California.
186. *enigma* Scudd.—Arizona.
187. *gracilis* Bruner.—Nebraska, Dakota.
188. *glacialis* Scudd.—New Hampshire, British America.
189. *mancus* Smith.—Maine.
190. *borckii* Stål.—California, Oregon.
191. *zimmermannii* Sauss.—Carolina.
192. *longicornis* Sauss.—Carolina.
193. *nebrascensis* Thomas.—Nebraska.
194. *unicolor* Thomas.—Illinois.
195. *edax* Sauss.—Carolina.
196. *scudderi* Uhler.—Maryland, Illinois.
197. *borealis* Scudder.—Minnesota.
198. *septentrionalis* Sauss.—Labrador.
199. *pacificus* Scudd.—Western United States, California.
200. *occidentalis* Bruner.—Nebraska.
201. *albus* G. M. Dodge.—Nebraska, Minnesota.
202. *junius* G. M. Dodge.—Nebraska.
203. *autumnalis* G. M. Dodge.—Nebraska, Dakota.
204. *pictus* Thomas.—Nebraska, Kansas, Colorado, &c.
205. *Bradyonotes opimus* Scudd.—California.
206. *obesus* Thomas.—Montana.
207. *Hesperotettix viridis* Scudd.—Utah, Colorado, Nebraska, Minnesota, Kansas, &c.
208. *Caloptenus extremus* Walker.—British America.
209. *arcticus* Walker.—British America.
210. *borealis* Fieb.—British America.

211. *Caloptenus bilituratus* Walker.—Pacific Coast, Montana.
212. *punctulatus* Uhler.—Maine, Massachusetts.
213. *minor* Scudd.—Mississippi Valley.
214. *gracilipes* Scudd.—(?)
215. *deletor* Scudd.—Texas.
216. *robustus* Scudd.—Texas.
217. *turnbullii* Thomas.—Pacific coast.
218. *floridanus* Thomas.—Florida.
219. *angustipennis* G. M. Dodge.—Nebraska.
220. *plumbum* G. M. Dodge.—Nebraska.
221. *differentialis* Thomas.—Nebraska, Iowa, Illinois, Missouri, &c.
222. *griseus* Thomas.—Ohio, Nebraska.
223. *scriptus* Walker.—Pacific coast.
224. *occidentalis* Thomas.—Montana, Colorado, &c.
225. *yarrowii* Thomas.—Arizona or Nevada.
226. *regalis* G. M. Dodge.—Nebraska, Colorado, Wyoming.
227. *helluo* Scudd.—Texas.
228. *ponderosus* Scudd.—Texas.
229. *flavolineatus* Thomas.—Florida.
230. *keeleri* Thomas.—Florida.
231. *volucris* G. M. Dodge.—Nebraska.
232. *clypeatus* Scudd.—Georgia.
233. (*Melanoplus*) *femur-rubrum* Deg.—United States, British America.
234. *collinus* Scudd.—Vermont.
235. *femoratus* Scudd.—Washington Territory, Maine, South Carolina, British Columbia, &c.
236. *atlanis* Riley.—Northern United States and British America.
237. *rectus* Scudd.—Maine.
238. *luridus* G. M. Dodge.—Nebraska, Dakota, &c.
239. *collaris* Scudd.—California.
240. *devastator* Scudd.—Montana.
241. *cinereus* Scudd.—California, Nevada, Washington Territory, &c.
242. *spretus* Uhler.—Western United States and British America.
243. *packardii* Scudd.—Washington Territory, Colorado, Utah, Nebraska, Texas.
244. *kennicottii* Scudd.—British America and Alaska.
245. *bivittatus* Scudd.—Eastern and Central United States, British America.
246. *tenebrosus* Scudd.—North Carolina.
247. *arizonæ* Scudd.—Arizona.
248. *infantilis* Scudd.—Colorado, Wyoming, British America, &c.

249. (*Melanoplus*) *variolosus* Scudd.—Kansas, Colorado.
250. *flabellifer* Scudd.—Colorado.
251. *fœdus* Scudd.—Colorado.
252. *curtus* Scudd.—Colorado.
253. *interior* Scudd.—Arizona, Utah, &c.
254. *bowditchii* Scudd.—Colorado.
255. *flavidus* Scudd.—Colorado, Nebraska.
256. *nigrescens* Scudd.—Georgia.
257. *Paroxya atlantica* Scudd.—Atlantic coast, &c.
258. *recta* Scudd.—Georgia, Florida.
259. *Tettix ornatus* Harris.—British America, New Mexico.
260. *arenosus* Burm.—South Carolina, Florida.
261. *cucullatus* Burm.—Massachusetts, Missouri, &c.
262. *femoratus* Scudd.—Maryland.
263. *triangularis* Scudd.—Massachusetts, Maine, New Hampshire, &c.
264. *rugosus* Scudd.—Florida.
265. *oxycephalus* Burm.—South Carolina.
266. *harrisii* Packard.—Maine.
267. *granulatus* Scudd.—Eastern North America.
268. *Tettigidea lateralis* Scudd.—Florida, Eastern United States.
269. *polymorpha* Scudd.—Eastern United States.
270. *obesa* Scudd.—Georgia.
271. *prorsa* Scudd.—Georgia.
272. *Batrachidea cristata* Scudd.—Florida, Massachusetts.
273. *carinata* Scudd.—Massachusetts.

This list I do not consider perfect in any respect, nor do I claim any merits for it; on the contrary it possesses many faults, both in the order in which the names occur and in the names themselves. However this may be, it will answer the purpose for which it is designed, viz., to show the great numbers of this family of insects that inhabit our country. But few of these species are known to the general class even of entomologists, and fewer to those who take no interest in the insect life about them. By a careful study of these insects throughout the various portions of the unexplored regions of the West and Northwest, I am quite confident that many others will be added to this already large list. The habits and natural history, too, of most of these locusts, are but comparatively little understood, and there yet remains much to be learned.

THE WESTERN CRICKET.[7]

(*Anabrus simplex.*)

In various portions of the far West are to be found different species of large, wingless and dark-colored insects which distantly resemble

[7] Compare also the account of this cricket in the Second Report of the U. S. Entomological Commission, chapter VIII, p. 163.

true crickets. These insects belong to that large and variable group or family of Orthoptera the *Locustidæ*, or katydids and allies, but are known as Western Crickets. Of the genus *Anabrus* there are at least a half of a dozen species. One of them, however, has gained for itself a name that cannot soon be forgotten by the early settlers of Utah and adjoining territories. At times this insect became so numerous that in its marches great depredation was done to crops, and the early settlers were entirely despoiled of their agricultural products. Wheat, oats, and barley, as well as most garden products, were attacked with the utmost avidity, and when once in a field or garden this insect would not leave without having first eaten everything—the weeds even being included among the rest, and in many cases devoured close to the ground.

This insect is known popularly as the Cricket, the Western Cricket, Buffalo Cricket, &c., and scientifically as *Anabrus simplex*. Its distribution appears to be coincident with that of *C. spretus* west of the main divide of the Rocky Mountains, but it is confined to the more elevated sage wastes and mountain valleys, as well as the open slopes high up the mountain sides. In fact, as a rule, it keeps up among the mountains, and only occasionally comes down into the valleys on marauding expeditions.

The cricket, like the locust, was not known until emigrants and gold-seekers began to cross the continent, and then only was it heard of as having been seen in the vicinity of Great Salt Lake and along the old Military Road. Since the locust question came up, however, its known range has greatly increased, and now we are aware of its existence as far north and west as Pend d'Oreille Lake and the eastern half of Washington Territory. Oregon too, occasionally, is reported as having its share of vast herds of crickets, while Nevada is occasionally visited by them. In Utah they occasionally appear as far south as Mount Nebo. They travel in droves or herds, which come marching along over the country like an army intent upon razing to the ground everything that lies in its line of march. These armies vary greatly in size and in their tactics while on the move. As a rule they collect into lines varying from a few to hundreds of yards in width, and from a few hundred feet to a mile or more in length. When they are ready to move, a few of them start off in the direction in which they intend to go, and are followed by others, and these again by still others—all taking the same route, and thereby exhibiting the leading character in the moving or migrating of wingless insects. Ants and termites also possess this peculiar habit, as do several species of crustaceans that at times are in the habit of changing their abodes or of traveling in search of food.

The natural history and habits of this cricket are but little known as yet, since their usual haunts and breeding grounds lie far up in the mountains and out among the sage wastes of the foot hills. Here it is that they generally pass their lives and propagate their kind year after

year, devouring the wild grasses and herbs. At times, through some unnatural increase or the scarcity of food in these localities, or, perhaps, from the perfecting of some latent desire to roam, they make the appearance for a short time, and then are off again for the uplands, to remain a mystery for another indefinite number of years. I was really surprised at the ignorance displayed by many of the inhabitants of the Western Territories, many of whom were of the opinion that they are of the nature of the cicadas and other periodical species. As wide as the distribution of this insect is, the locality, however, where they are the most numerous is the lava region along the valley of the Snake River. Here it is that we hear of them in greater or less numbers every year.

This year I heard of crickets throughout Idaho, Montana, and eastern Washington Territory, and was fortunate enough to meet a gentleman (Mr. A. Bowen, of Colfax, W. T.) who was able to give me some information in reference to their breeding habits in the eastern portion of Washington Territory. The following is the natural history of these insects, as given by him:

Crickets are frequently seen in large numbers at different localities throughout eastern Washington Territory, and at times have done considerable damage to crops, vegetables, and grasses. That they should occasion great alarm when appearing in such vast droves is quite natural; but, in reality, they are not so dangerous as might be supposed, since they are very easily checked in their march by ditches, and can be readily destroyed. If a ditch two feet wide and two and a half deep be dug across their line of march they will fall into it and cannot get out. By putting in larger pits at intervals they are doubly "corralled," and soon begin destroying one another, as they are great cannibals. Rolling the ground, too, is of considerable aid toward diminishing their numbers.

When once started in a certain direction it is seldom that they turn aside for ordinary obstacles, but keep straight ahead until they "fetch up" in some creek, ditch, or pit, and are lost by drowning or by being devoured by their stronger neighbors and kinsfolk.

In speaking of this insect Mr. Bowen said that "the young were so small when first hatched that they could hardly be seen," but in a few days they molt and become perceptibly larger. This "shedding" is repeated several times, until they have finally attained full size, after which they become quite dark colored. When ready to molt they climb up a blade of grass, weed, or some other object, to which they cling while going through the process; after which the skin of the cricket first cracks open on the back like a cicada, and the new insect comes out "fresh and green," but soft. Sometimes the shell is eaten, but generally is left clinging where it was shed.

In early spring when they are just hatched the little fellows are found in clusters of twenty to forty—probably the offspring of a single female, or more likely of a single batch of eggs. These young as they increase in size spread from time to time until they form circular droves with a diameter of twenty or more feet, and finally the various broods become so intermingled that they are no longer discernible.

It has often been a query with the settlers of various portions of the

"cricket area" of the West, whence do the great numbers of this insect come after a series of years in which comparatively few or none have been noticed, and some even assert that they only mature after a period of seven years or at other definite intervals. Mr. Bowen's idea, however, is that they are annual in their generation, and are noticed only after a winter favorable to the preservation of their eggs, which are mostly destroyed in other years. He thinks that small droves are annually bred at isolated localities, and spread over a large area to deposit their eggs. In these views I coincide, although I must confess that I have had no personal experience with this insect.

A year when crickets were bad in Pleasant Valley, eastern Washington Territory, as well as in many other localities in this Territory, was that of 1873. At that time, however, but little farming was carried on in this district, and hence the damage occasioned by them was light. Again, in 1877, some were seen in the neighborhood of Colfax, but these did not appear to come in contact with many fields of grain or gardens in their marches. Since, and prior to this, small droves have been reported as having been seen in various portions of this and adjoining portions of Oregon and Idaho.

I could supplement this list with many more accounts of the appearance of this insect, but they are all of a similar character, and hence of no particular interest here.

But few parasites are known to affect this cricket. Further investigations may greatly enlarge the list, however. In the summer of 1878 large numbers of this insect were seen along the Portneuf River. A few of them were attacked by red mites much like those infesting the migratory and other locusts. These were clinging to them at various points, but chiefly about the thorax and rudimentary wings. I do not know, but suppose they are the young of some egg-eating mite—perhaps one that attacks the eggs of this and other crickets. I have also been told that various ground-beetles and sand-wasps destroy some of their young. Hair-worms (*Gordius*), too, are frequently found wound about their intestines. Besides these insect enemies there are numerous species of birds that devour great numbers of them. Fishes, too, capture large numbers as they cross streams.

This is all that I will mention at present in connection with this insect, but hope some time in the future to be able to give its full history.

Respectfully yours,

LAWRENCE BRUNER.

Prof. C. V. RILEY,
United States Entomologist,
Washington, D. C.

CHAPTER V.

DATA OBTAINED FROM SOLAR PHYSICS AND EARTHQUAKE COMMOTIONS APPLIED TO ELUCIDATE LOCUST MULTIPLICATION AND MIGRATION.[8]

This noble lantern of the world, the all-vivifying, pulsating heart of the universe, in the opinion of Baron von Humboldt, was the primary source of light and of radiating heat, and the generator of numerous terrestrial electro-magnetic processes, as indeed of the greater part of the organic activity upon our planet. It is the sun-power that gives rise to alterations on the surface of the earth, and that conjoins with lunar attraction in producing the mounting of the spring-tide. It is the solar rays that move the atmospheric and oceanic currents; that evoke the colored coruscations of the polar light; thunder and lightning, hurricanes and waterspouts, speak of their action; and it is no less the solar rays that evoke the all-silent forces of chemical attraction and that variously determine organic life in the endosmose of cell-walls and in the tissue of muscular and nervous fibers (Cosmos, Trans. by Otté and Paul, p. 359). This portion of solar physics is now so generally understood that it becomes unnecessary to adduce the opinions of other learned authors, or to refer to an endless and mundane bibliography; although it may not be out of place to remark, that the conception of the sun being a great electro-magnetic globe would seem to possess no small claim to be considered the predominant one; and many doubtless are of opinion that the stellar forces of rotation, revolution, oscillation (nutation and obliquity of the ecliptic), gravitation, and chemical affinity, should be considered as phenomena induced by its action. (I notice an observation on this subject in the Journal of Science for March, 1882, p. 122.)

Be this inference as it may, certain is it that the scientific mind since the days of Humboldt has become gradually reawakened to the circumstance that a large class of terrestrial phenomena on which mankind depends for the future development of its resources are not only ruled by the earth's diurnal revolution and annual circuit round the sun, but are likewise immediately controlled by a recurring variation in the potent energy of the central luminary of our system itself. Terrestrial

[8] Prepared and communicated to the Commission by Mr. A. H. Swinton, of Binfield House, Guildford, Surrey, England, who has given much attention to insect periodicity and to whom we hereby tender our acknowledgements without endorsing all the author's views.

magnetism, electrical activity, periodical variations in temperature, periodicity of wind disturbance, and annual rainfall have especially occupied attention in this respect; and their cycles following responsively on the changes in the bright photosphere surrounding the sun, have been observed, registered, and drawn up in tables. From these indices we may now glean that as this bright atmosphere of light every eleven years or so becomes ragged with spots and then replenishes its shining,[9] so do cold and warm seasons, cyclones and rainfall, disturbances along the electric wire, compass oscillations, auroral displays, and other sun symptoms in our sky and soil, follow each other in due sequence. Medical science, too, has not been oblivious of these sun periods, and not a few attempts have been made to correlate them with seasons of famine, plague, cholera, and other epidemic visitations. (A pestilential cycle, according to Dr. John Parkin, extended from 1600 until about 1700, and another began with the nineteenth century. Journal of Science, August, 1881.)

In the cloud-driven and inconstant climate of northern Europe the procession of the seasons daily chronicled in the horizontal swing and vertical dip of the compass needle, would appear from all accounts to be both complex and difficult to unravel; and the same remark, I think, applies to the tracts of northern America. Indeed, it would appear hitherto as though the electrical storms and increasing frequency in the display of auroral lights, the wind commotions, and perhaps rainfall coming on about the maximum period of sun-spots, and the heat waves characterizing the minimum period are to be considered as the most obvious and best established features in our solar drama. Electrical storms were felt along the English telegraphic wires in the years 1848 and 1859, and again, last August (1881), we hear of the compass needle being affected (English Mechanic, of Friday, December 9, 1881). During

[9] *Sir John F. W. Herschel's description of the sun spots.*

When viewed with powerful telescopes, provided with colored glasses to take off the heat, which would otherwise injure the eyesight, the sun is observed to have frequently large and perfectly black spots upon it, surrounded with a kind of border, less completely dark. These spots are, however, not permanent. When watched from day to day, or even from hour to hour, they appear to enlarge or contract, to change their forms, and at length to disappear altogether, or to break out anew in parts of the surface where none were before. In such cases the central dark spot always contracts into a point, and vanishes before the border. Occasionally they break up or divide into two more, and in those offer every evidence of that extreme mobility which belongs only to the fluid state, and of that excessively violent agitation which seems only compatible with the atmospheric or gaseous state of matter. Their size has been computed at from 465 to 45,000 miles linear diameter, and some are said to reach a greater extent. That part of the sun's disk not occupied by spots is far from uniformly bright. Its ground is finely mottled with an appearance of minute, dark spots or pores, which, when attentively watched, are found to be in a constant state of change. There is nothing which represents so faithfully this appearance as the slow subsidence of some flocculent chemical precipitates in a transparent fluid, when viewed perpendicularly from above. Lastly, in the neighborhood of great spots, or extensive groups of them, large spaces of the surface are often observed to be covered with strongly marked curved or branching streaks more luminous than the rest, and among these, if not already existing, spots frequently break out. Only one notion among the many that have been broached has gained acceptance in regard to the spots, namely, that they are the dark, solid body of the sun itself, laid bare to our view by those immense fluctuations in the luminous regions of its atmosphere to which it appears to be subject. The region of the spots is confined within about 30° of the sun's equator, and from their motion on the surface, carefully measured with micrometers, is ascertained the position of the equator and period of the sun's rotation, &c.—(A Treatise on Astronomy, by Sir John F. W. Herschel, pp. 207-211.)

the year 1870, another epoch of maximum sun-spots, no such disturbances, if prevalent on the continent, intruded themselves into notice in this country; but on the nights of the 24th and 25th of October a very fine display of crimson flashes broke over the roofs and spires of London, showing that the earth condenser, according to M. De la Rive's theory, then shot its discharge currents into the higher atmosphere. Other auroras were observed on the 5th of April, 1870, and on the 15th of April and 13th of May, 1869, the former being noticed in America. (There is a good chart showing the agreement of the Magnetic Diurnal Range and Sun-Spot Curves between the years 1841 and 1877, by Mr. Ellis, in the Philosophical Transactions for 1880.)

Turning from electricity to meteorology, a subject more immediately affecting the present inquiry, we find that Prof. Piazzi Smyth, the Astronomer Royal for Scotland, as the result of observations made from 1837 to 1869, with thermometers sunk in the rock at the Royal Observatory, Edinburgh, came to the conclusion that a great heat wave occurs every eleven years and a fraction, its maximum slightly lagging behind the minimum of the sun-spot cycle. Previously Professor Balfour Stewart had found that the winter temperature-range at Kew *apparently* depends on the sun-spot period, being greatest at times of maximum sun-spots, and least at times of minimum sun-spots. At the epoch of maximum sun-spots wind disturbances are most frequent, as is shown in a wreck chart by Messrs. Jeula and Hunter, and coupling this observation with the previous, I think it may be fairly argued that we about this time (and at the minimum epoch?) have our open winters. According to the observations of Schwabe and some recent mean temperature statistics from the Times newspaper I have by me, this is a wet as well as a windy conjuncture, and according to Herr Gustav Wex it is the time when there is most water in the European rivers. (The river inundations, due often to local causes, do not, nevertheless, follow this law; take for example those of the Garonne that have occurred in 1425, 1537, 1599, 1727, 1772, 1790, 1827, 1835, and 1875.) Still, with all this instrumental work indicated or accomplished, there remain over and above, in the experience past and present, many strongly marked features in the climate of Europe that might repay the trouble of erudite tabulation on the one hand and of scientific investigation on the other. Thus while some winters have been intensely cold (those of 401, 554, 800, 821, 1116, 1213, 1234, 1432, 1433, 1434, 1579, 1683, 1708, 1716, 1739, 1753, 1762, 1766, 1776, 1784, 1795–'6, 1797, 1813, as would seem), others have been as inordinately warm (those of 1183, 1288, 1572, 1621, 1658, 1685, 1703, 1760, 1858, 1865, 1868, 1876, 1880, might be examined in this respect), and late and early winters and springs are quite as much a matter of comment as warm (the summers of 763, 1333, 1556, 1651–'56, 1766, 1783, 1788, 1811, are alleged to have been hot) and cold summers.

Within and towards the tropics, as has ever been the opinion, the solar phantasmatography presents its phases with greater regularity before

the eye of the observer, and in corroboration of this testimony Dr. W. Köppen, who has drawn up a table of the earth's temperature in connection with the sun-spots between the years 1770 and 1870 (Zeitschrift der österreichischen Gesellschaft für Meteorologie, August und September, 1873), informs us that within the tropics the maximum warmth occurs a full year before the year of minimum sun-spots, while in the zones beyond it falls two years after the minimum, and that the regularity and magnitude of the undulations of the temperature curve is most strongly marked within the tropics and decreases toward the poles. During this heat which accompanies the minimum epochs, droughts may be looked for, and likewise famines, according to Mr. W. W. Hunter's tabulation.

Last, not least, in addition to these sun features now detailed, seismic phenomena, such as earthquakes, volcanic emanations and hot springs, and entomological phenomena, such as insect multiplication and migration, are proclaimed by the voice of all antiquity to result from excessive heats and dry seasons, and to be the fell accompaniments of famines and pestilence. Even now in the picturesque language of the Arabs we find such phraseology as the year of the drought, the year of the earthquake, the year of the locust, and the year of the whirlwind, showing that an interest is still felt in the dark numbers of astronomy, and revealing the sources of a science we northern nations are far too apt to cavil at. But of this anon. On the other hand, about the maximum sun-spot years the cyclones in the Indian Ocean and the hurricanes in the West Indies, as has been shown by Messrs. Meldrum and Poëy, increase in number, and at the same time the annual rainfall is greatest in the East Indies and at the Cape of Good Hope. (Messrs. Norman Lockyer and Hunter in the Nineteenth Century for November, 1877 (p. 583), furnish a digest of the more recent application of Solar Physics to Terrestrial Phenomena, entitled "Sun-spots and Famines".) Indeed the increase in wind-disturbances and rainfall would seem to be the leading feature of the maximum period of sun-spots all over the globe, a consequence which some tacitly assign to the greater energy of the sun at this period. Should, however, this conception seem discordant with a notion of the heat waves at the minimum period and the existence of permanent defects in the luminous photosphere of the sun at the maximum, the wind and rain would quite as agreeably with the known laws of nature be referred to the irregular action and impotent state of the sun at this conjuncture, producing secular refrigeration, and increasing in this manner the aerial currents and precipitation of aqueous vapor. Certain is it that Sir William Herschel's comparison between the prices of corn and complaints of poor crops in Europe, as founded on the first hypothesis, could not be borne out by the past wretched years. (Phil. Trans. 1801, pt. ii, pp. 310–316).

Having thus in a general way introduced my subject in its various bearings, I will now proceed to show how solar physics influence insect multiplication and migration in general, and locust multiplication and

migration in particular. But since it will be necessary, before entering on a disquisition upon these terrestrial phenomena, to have an extended notion of the solar phases that I hope then to show regulate their periodicity, I will proceed to construct a new sun-spot table exhibiting the solar maxima and minima of maculæ between the years 1880 and 1500. I awoke to a realization of this undertaking in the spring of the year, when strolling alone over the winter-scorched grass that covers the old earthquake waves on the Surrey Downs, but I have found since that the possibility of such an enterprise would be conceived by the perusal of a pamphlet by Prof. Carl Fuchs, entitled Die vulkanischen Erscheinungen der Erde, published in 1865, and also that a few unknown epochs had already been taken out by the method which then recommended itself to me from its accuracy by M. Poëy (Comptes Rendus, t. LXXVII, pp. 51–53). The following are Dr. Fuchs's remarks: "Kluge macht in seiner Zusammenstellung der Eruptionen mehrfach auf das Zusammentreffen vulkanischer Ausbrüche mit kosmischen Prozessen aufmerksam. Es ergibt sich nämlich aus der Zusammenstellung der Minimal- und Maximaljahre der Sonnenflecken und der vulkanischen Eruptionen, dass sonnenfleckenarme Jahre, die sich zugleich durch geringere Grösse der magnetischer Variationen auszeichen, zu den eruptionsreichen Jahren gehören und umgekehrt. Das Jahr 1822 wurde an einer früheren Stelle als ein solches genannt, welches sich durch die Menge von Eruptionen auszeichnet, die während desselben stattfanden; dasselbe Jahr zeichnet sich aber auch als Minimaljahr von Sonnenflecken aus und in gleicher Weise die Jahre 1793, 1843, 1855. Im Jahre 1769 betrug nach R. Wolf die Relativzahl der Sonnenflecken 85.7 und kein einziger vulkanischer Ausbruch ist in diesem Jahre bekannt. Im Jahre 1799 betrug die Relativzahl der Sonnenflecken 99.2, im Jahre 1788 aber 90.6, und im ersteren Jahre fanden 4, im letzteren 5 Eruptionen statt. Dagegen wird die Relativzahl der Sonnenflecken im Jahre 1756 zu 8.8 angegeben und die von 1798 zu 2.8, während in dem zuerst genannten Jahre 12 und in dem andern 10 Eruptionen stattfanden. Im Jahre 1843 war die Relativzahl der Sonnenflecken 8.6, die Zahl der Eruptionen betrug 32." (Die Vulkanischen Erscheinungen der Erde, von Dr. C. W. C. Fuchs, Docent an der Universität in Heidelberg. Leipzig und Heidelberg, 1865.)

The following is a résumé of M. E. Kluge's views: "M. R. Wolf (Bern. Naturf. Gesellschaft, 1852) avait énoncé, d'après une chronique Zurichoise pour les années de 1000 à 1800, que les aurores boréales et les tremblements de terre s'accumulent sur les années de taches. M. E. Kluge soutient, au contraire, que dans les années abondantes en taches solaires et où les variations magnétiques sont plus remarquables, les éruptions volcaniques et les tremblements de terre sont aussi plus rare." (Ueber Synchronismus und Antagonismus von vulkanischen Eruptionen, und die Beziehungen derselben zu den Sonnenflecken und

erdmagnetischen Variationen, von E. Kluge. Leipzig, 1863. 102 pp., 1 pl., 8vo.)

Whether any one has previously taken up the question in its entirety I cannot say. (The lunar disturbance of gravity that excited attention at a recent meeting of the British Association does not influence the *prima facie* case. H. E. H. Darwin, Rep., 1881). Councillor Schwabe, of Dessau, was, according to Humboldt, the first to tabulate numerically the solar spots, and his tables, published originally in Schumacher's Astronomische Nachrichten, No. 495 (Bd. XXI, 1844), p. 235, and afterwards more fully given in the fourth volume of Cosmos, show the fluctuations of the solar photosphere between the years 1826 and 1850, from actual eye observation. Schwabe's table has been sub equently enlarged by other workers, Professor Wolf carrying it back to 1750 and forward to 1860 and 1875, and pointing the maximum of spots of 1828 in Schwabe's table as 1829. The axiom I have employed in carrying the sun-spot cycles farther into the past, will be seen then to be justified by a reference to M. Poëy's table of earthquakes and volcanic eruptions in the Brazils, in the Comptes Rendus, already alluded to; it assumes that the great periods of earthquake-commotion and volcanic activity harmonize with the maxima and also with the minima periods of solar spots; and on this assumption I have consulted various seismic tables and checked off the periods of disturbance by the records which in their copiousness or defect fully indicate the required discontinuity recurring at stated intervals. But when these periods were found it further became very evident to me that it was necessary to adopt some method of numerical precision in order to eliminate the years of the sun-spot cycles. To this intent, therefore, I first drew up the mean periods of greatest commotion in Europe, Asia, and America, and placed the maxima and minima of sun-spots given in Wolf's table into the breaks, where they fell in order, I think I may say, at first sight. I then took out the latter extreme year and the mean year for the minima years, and the former extreme year and the mean year for the maxima years. One or other of the numbers, which themselves rarely differed by more than a year, should give me as I found the epochs of fewest or most spots required.

To explain more fully, let us examine the list of earthquakes and volcanic eruptions for any breaks in the violence and extent of the disturbances and mark the periods obtained in this manner, thus (1839–1838). We will then arrange these periods of activity taken out from many tables, thus:

TABLE I.—*Mean seismic (earthquake and volcanic) periods and sun-spot cycles, auroras, progressive E. and W. deviation in the magnetic needle, and locust periods in Europe.*

	Maximum and minimum of sun-spots	Mean periods of seismic commotion in Europe and South America.	Differences.	Years of maximum and minimum of sun-spots.	Remarks.
Few auroras	M	(-1878)		1881	
	m	(1875–1872)	5	1876	Locusts.
	M	(1871–1870)	6	1870	
	m	(1868–1865)	3	1867	Locusts.
	M	(1862–1858)	7	1860	Locusts.
	m	(1855–1851)	5	1855	
	M	(1851–1846)	7	1848	} Locusts.
	m	(1844–1841)	5	1843	
	M	(1839–1836)	6	1837	
	m	(1833–1831)	4	1833	
	M	(1830–1828)	4	1829	} Locusts.
	m	(1825–1820)	6	1823	
	M	(1821–1816)	7	1816	
	m	(1812–1809)	6	1810	
	**W		6		
	M	(1806–1801)		1804	} Locusts.
	m	(1798–1795)	6	1798	
	M	(1792–1788)	10	1788	
	m	(1785–1783)	4	1784	
	M	(1781–1779)	6	1778	
Many auroras	*m*	(1776–1775)	3	1775	
	M	(1773–1770)	6	1769	
	m	(1768–1775)	3	1766	
	M	(1762–1759)	5	1761	} Locusts.
	m	(1755–1754)	6	1755	
	M	(1752–1759)	6	1750	Locusts.
	m	(1746–1742)	6	1744	
	M	(1739–1735)	7	1737	
	m	(1730–1729)	6	1730	Locusts.
	M	(1726–1724)	6	1724	
	m	(1721–1717)	4	1720	
	M	(1715–1713)	6	1714	Locusts.
	m.	(1708–1706)	6	1708	
	M	(1703–1702)	5	1703	
	m	(1699–1696)	5	1698	
	M	(1693–1691)	7	1691	} Locusts.
	m	(1689–1685)	3	1688	
	M	(1683–1681)	7	1681	
	m	(1679–1677)	3	1678	
	M	(1673–1671)	7	1671	
Few auroras	*m*	(1668–1664)	4	1667	
	M	(1662–1654)	10	1657	
	m	(1654–1653)	3	1654	
	M	(1650–1647)	6	1648	} Locusts.
	m	(1646–1643)	3	1645	
	M	(1641–1639)	5	1640	
	m	(1636–1633)	5	1635	
	M	(1628–1626)	7	1628	
	m	(1626–1624)	3	1625	
	M	(1620–1617)	7	1618	
	m	(1613–1612)	5	1613	Locusts.
	M	(1610–1606)	5	1608	
	m	(1603–1600)	5	1603	
	M	(1594–1596)	6	1597	
	m	(1593–1586)	4	1593	
	M	(1584–1581)	10	1583	
	**E		6		
	m	(1578–1576)		1577	
	M	(1574–1571)	7	1570	Locusts?
Many auroras	*m*	(1566–1563)	6	1564	
	M	(1561–1558)	6	1558	
	m	(1556–1553)	3	1555	Locusts.
	M	(1551–1548)	6	1549	
	m	(1546–1542)	5	1544	Locusts.
	M	(1542–1536)	7	1537	
	m	(1534–1528)	6	1531	Locusts.
	M	(1522–1519)	10	1521	
	m	(1516–1513)	6	1515	
	M	(1510–1509)	6	1509	
	m	(1507–1503)	4	1505	
	M	(1501–1495)	6	1499	

[14](1839–1838)			(1826–1823)
[13](1838–1834)	(1831)	(1830–1829)	(1826–1817)
[12](1839–1837)	(1835–1832)	(1830–1828)	(1825–1822)
[11](1839–1835)	(1833–1831)	(1829–1827)	(1825–1822)
[10](1839–1835)	(1833–1831)	(1830–1827)	(1825–1819)

Let us now mark the epochs of the sun-spot cycle *m* minimum or *M* maximum, as known from Wolf's tables, to the breaks to which they appertain, and at the same time find the mean periods of commotion, thus: (1839–1836) M^1 (1833–1831) m^2 (1830–1828) M^3 (1825–1820) m^4· where taking extremes and means $M^1=\frac{1836}{1837}$, $m^2=\frac{1833}{1832}$, $M^3=\frac{1828}{1829}$, $m^4=\frac{1825}{1822}$, the actual years here indicated being given by Wolf as 1837, 1833, 1829, 1823. Here the position of the years is evidently correctly found, the maximum in each case being the mean year of commotion and the minimum the latter extreme, but, as seen by the last fraction, an irregularity does sometimes occur. In calculating out the table, however, the latter inconvenience is almost *nil*, as it will be noticed that the known maxima and minima in Wolf's table have certain corresponding intervals of years 6–4, 4–6, 6–7, &c.; and also a certain final digit as far as they go, the maxima ending in a 7, 9, 6, &c., and the minima in 3, 3, 3, 0, &c.

Having thus correctly taken out the sun-spot numbers in cycles from the seismic breaks between the years 1881 and 1750, we may now proceed with confidence to tread on the confines of the unknown, and complete the series of maximum and minimum years back to 1500. Beyond this point, the grand epoch when Columbus opened up for eastern civilization a new continent, and when printing was commenced, the data in the seismic tables become involved and partial, and here, at the most, I have up to the present only been able to obtain a certain number of probable epochs of the solar phases. Sufficient data, however, will be found to be present in my table on which to string the more certain records of locust multiplication and migration, as known to myself from the exhaustive paper by Mr. Thomas in a former issue of your valuable report, relating fully the Old World locust multiplication during the seventeenth and eighteenth centuries, and from my own investigations regarding their increase during the nineteenth; as also from those clear indications afforded in Mr. Packard's concise list of the *C. spretus* years in America. But before entering on this subject I ought to mention that some of the breaks in my table are substantiated by eye observation. Thus Flamsteed tells us that the solar spots were absent between the years 1676 and 1684, and according to Dominique Cassini they were

[10]From Eruptions in Iceland, by Thoroddsen (*Trans.* Geol. Mag.).
[11]From Mons. Perrey's Earthquakes in Greece and Syria.
[12]From Mons. Poëy's Earthquakes in South America.
[13]From Mr. Mallet's List of Earthquakes and Volcanic Eruptions (Brit. Assoc.).
[14]From works of Lyell and Humboldt.

again absent between 1686 and 1688; other observers found them absent between 1695 and 1700. The means of these periods arranged by the differences of the series check the seismic numbers correctly, but as regards the maximum in 1681, it becomes evident that the observation of Flamsteed is indefinitely given, as it makes a greater interval occur between the minimum and maximum of the cycle than between the maximum and minimum. In M. Poëy's table, before alluded to, the following years are further given from the strength, number, and extent of the earthquake shocks in the Brazils, namely: 1727 M, 1712 *m*, 1693 M, and 1634 M. These in my table stand as 1730 *m*, 1714 M, 1691 M, and 1635 *m*, the modification being due to the co-ordination of other seismic data and the consecutive marking of the solar phases, only then rendered possible. Again, it will be noticed that the cycles of sun-spots in my table grow short about the beginning of the seventeenth century and lengthen out at the commencement of the nineteenth. This circumstance is owing, as I conclude, to the presence of a greater sun-spot cycle stretching from 1580 to 1814 and marked by the progressive east and west deviation of the compass needle. The years 1580 and 1814 on this greater cycle I would consider to correspond with the maxima of the smaller cycles, and some intermediate epoch about 1640 to correspond with the minimum. This would also answer well to the periods of prevalence and scarcity of auroras in Europe. Thus between 1574, about, and 1635, many auroras were observed; few were observed between 1635 and 1706; and many were again observed between 1706 and 1842. We are now in Europe back again in the period of few auroras, and I conclude at a minimum point in the greater sun-spot cycles, when, judging from the past, great extremes of summer and winter temperature may be anticipated.

Having drawn up my table, now comes the second clause of the inquiry, namely, how and in what measure the sun phases influence the world of insects on the surface of the old and new continents. Before setting out on this subject, however, I think it may be inferred that where the terrestrial phenomena follow most directly on the changeful glare of the solar photosphere, there shall we find the various features of insect biology marshaled in the strictest order. As before noticed, this phenomenon is to be looked for rather towards the equator than in the direction of the poles of the diurnal sphere, and here it is that insects should be found to multiply and migrate in most immediate dependence on the sun changes. Let us take that example which most concerns us, the Rocky Mountain locust (*Caloptenus spretus*). The Permanent Region, and native breeding-ground of this insect, as already ably shown by the entomologists on the Commission, lies within the northern temperate zone, between 37° and 53° north latitude. Though somewhat removed from the tropics, the summer isotherms would adjudge it to be considered within tropical influence, and this even more so than Southern Europe, which must be virtually so considered. The migra-

tions of the locust have been, broadly speaking, in a southerly direction east and west of this region, and if reference be made to Mr. Packard's analytical table given in the report of the Commission for the year 1877 (p. 113), and the year 1878–'79 (p. 111), we shall find that these have waxed and waned, that one climax transpired between 1874 and 1876, that another transpired between 1866 and 1867, that another transpired between 1855 and 1857, and there remains besides some indications of an invasion about 1842. Now by Wolf's tables of sun-spots 1876, 1867, 1855, and 1843, severally tangential numbers, are the years of fewest sun-spots as determined by observation. In this case therefore the season of multiplication and migration has preponderated to the minimum period of solar spots; and conversely about 1848, 1860, 1870, and as I conclude also in 1881, the intermediate years of most sun-spots, the decrease and restriction of this locust are equally apparent.

But to fully illustrate this subject, I will turn to the insect multiplication and migration of the Old World, where the data are more copious and the subject matter more familiar. Here we know as regards the multiplication and migration of various locusts in the cereal districts on the southern borders of Europe and Northern Asia, from long tradition since the earliest days, that those droughts which have been previously attributed to the minimum epochs of the sun-spot cycle are their season of increase. But, as I have already intimated (Journal of Science for August, 1881), it cannot be therefore assumed that all destructive insects on European areas have the same period of multiplication; for while the corn weevils (*Sitophilus granarius* and *oryzæ*) of our granaries, or certainly the more destructive sort which is imported from the marts of the south, have shown a tendency to increase about the minimum of spots, it would appear that the noxious European wheat flies (*Diplosis*), of which there are said to be two varieties, affect in Germany a decennial period recurring towards the maximum years. This phenomenon may be either attributable to the circumstance that insects are variously adapted to various conditions of climate, and that there are certain recurring times when certain families and certain individuals find themselves in the most congenial conditions for multiplication; or to the circumstance that there exist fixed epochs when a general north and west move is witnessed in the mass of the European insect fauna. These latter times or epochs, north of about 45° north latitude, alternate, as I shall proceed to show, with the extremes of solar energy, so that the great European migrations of insects take their rise in the years of minimum sun-spots, and continue until the expiration of the succeeding maximum. Let us exemplify this first, in passing, by Köppen's record of the migration of locusts to Southern Russia, given by Mr. Thomas.[15] Here there is a migration extending from 1756 to 1757 indicated, then a break until 1783, then another break until 1793, and

[15] Report of the Entomological Commission on the Rocky Mountain Locust, for 1878–'79, p. 41.

so on; each in every case, if we except the interval 1828–1836, where two cycles of migration seem to be run together, fairly indicating the interims between the years of solar energy as given from observation by Schwabe, Wolf, and others.

Now, then, for the great résumé of Európean locust migration. In the year 1527 locusts swept out of Turkey into Poland, and in 1536 they came from the Black Sea to Hungary, traversing Lithuania and Poland to Schleswig. In 1541 the locusts again visit Poland, and a great army flies through Germany into Italy, some passing forward over Silesia and Saxony, while others turn themselves toward Austria and Italy. The next year a swarm passes through Poland and Lithuania into Prussia and Silesia, spreading over a great part of Europe, and two years after there were said to be so many grasshoppers about Mismia that they covered the ground about a cubit thick. 1544 I doubtfully take out as a minimum year of sun-spots, from Mr. Mallet's seismic table. In the year 1553, after five years' drought, great armies of locusts were noticed, no locality being precised, and in two years' time we hear of them at Arles, and the next year in Mailand. 1555 or 1553 works out as a minimum year from Mr. Mallet's table. In 1571 and 1572 locusts ravage to such an extent in Italy that an edict is promulgated by the Vice Duke of Alcala regarding their destruction. Though this *multiplication* (?) evidently indicates a warm solar epoch, I, with some little hesitation, mark 1570 as a proximate *maximum* (?) of solar spots, the seismic data which give the year being somewhat perplexing. In 1613 locusts are destructive in Provence, and the year takes out very naturally as a minimum one from the seismic data. In 1618 and 1619 Spain is afflicted by a species of locust, but like all other records from Spain, this is yet as wanting to me in a *raison d'être* as the celebrated *château;* 1618 it may be noticed, is a *maximum* year of solar spots on my table. In 1645 and 1646 there was a plague of locusts in the Ukraine, 1645 here being evidently a minimum epoch of solar spots, as indicated by the seismic data. In 1650 Lithuania and Poland are visited by locusts, an invasion I would correlate with a minimum of sun-spots in 1654, and in 1662 we find the province of Puglia Daunia visited by locusts, the minimum of solar spots being found in 1667, or in 1654, if part of the former invasion. In 1684 an immense flight appears in Hungary and Austria, and the next year a swarm is noticed at Avignon. This multiplication forms a prelude to an invasion of Northern Europe in 1689, when the locusts, now abundant in the Ukraine, strike on the coasts of Lithuania and Poland, reaching to Volhynia, in Russia, during the succeeding year. In 1693 they sweep in large bands through Hungary, Bohemia, and Austria, into Germany, reaching Austria on the 3d of August, Jena on the 18th, and Weimar on the 20th. This invasion continues to show up in Germany until 1696. The year 1688, according to my table, indicates the minimum period of spots to which this influx would be referable.

After this marked inroad, concerning which Mr. Thomas has given so full a bibliography, the locusts in 1708 again sweep out of Wallachia and pass through Poland into Russia, and two years after they spread alarm through the army of Charles XII in Bessarabia, and in 1712 we hear of their passing through Galicia to Germany, and of their harassing Silesia. As would appear, this invasion continued for three or four years and extended into Italy; but since the minimum epoch of sun-spots transpired in 1708, some of the destruction committed in Italy about the year 1716 may have been due to the local multiplication of the *Caloptenus italicus*, and should be ascribed to the next period of solar energy culminating in 1720. As soon as 1727 the fields of Italy are again attacked by locusts, and in 1730 and 1732 they visit Germany and penetrate as far as Berlin; 1730 is here the proximate year of fewest sun-spots. The great locust inroad of this century, starting from Turkey in 1747, spread through Wallachia, Moldavia, Transylvania, and Hungary, and from thence in 1749 passed into Austria, Bavaria, and Germany, reaching Brandenburg in 1750. The Ukraine, Poland, and Silesia were also visited, and the swarm, attaining the shores of England, is stated to have been destructive in Norfolk, Stafford, Cheshire, and Derbyshire (?). The differences of the sun-spot series indicate a minimum year of sun-spots about 1744 or 1747 to which this invasion should be referred. In 1756 and 1757 locusts again migrate to Russia, and two years afterwards they are observed in Italy and Germany, where they are again noticed in 1763. The corresponding minimum year of sun-spots is in this case evidently 1755. In 1792 locusts visit Spain, and from 1799 to 1806 they migrate to Russia, appearing in Germany in 1803; 1798 is here the corresponding solar year.

Some notices of locusts in Europe during the seventeenth and eighteenth centuries seem to be apocryphal. F. Th. Köppen (Ent. Zeit. zu Stettin, 1871, S. 183–190) thinks some of the reputed invasions refer to troops of dragon flies.[16] He adds that during the years 1623, 1659, and 1695, as far as he was aware, there were no locusts in Germany. These migrations of dragon flies will be found tabulated in a brochure entitled Waarnemingen over het Trekken van Insekten door A. A. van Bemmelen; taking their origin in the variable climate of Europe, we find that while they fairly culminate towards the minimum times of sun-spots, they may likewise indicate the maximum epoch, as I think an analysis will show.

In the present century[17] we find various records of locust increase along a line extending from Egypt to India, during the period included between the years 1810 and 1814, and that simultaneously this tribe of insects is destructive in France, and that a migratory species, the *Pa-*

---

[16] 1494, S. Caspar. Weinrich. Danziger Chronik., herausg. von Hirsch und Vossberg. Berlin, 1855, 4°; 1586, Ditm. Chron. ii, 303; 1623, I. B. Carpzov, Analectis fastorum Zittanjensium. Th. 2, p. 284, vgl. Rathlef. Akridotheologie, Th. ii, 1750, pp. 60, 61; 1659, vgl. Rathlef. Akridotheologie, ib.; 1695, ib. ii, p. 80.

[17] Wm. Denison Roebuck's articles on locusts in Yorkshire contained in the Yorkshire Naturalist, compared with notices in the publications of foreign entomological societies and with notices in travelers' journals.

chytylus migratorius L., as would seem, visits England and the shores of the Baltic. In the period included between 1820 and 1828 Orthoptera again multiply, becoming destructive in the Crimea between the years 1823 and 1826. In 1825 *Caloptenus italicus* is noxious in Italy and in Southern France, and in the autumn of 1828 a remarkable cloud of locusts, most probably the *Pachytylus migratorius*, was noticed to pass from Odessa over to Galicia. During this period the last-mentioned species appears regularly in eastern and northern Germany.

We next hear of Orthoptera increasing in Europe during the period included between the years 1832 and 1834, when locusts were noxious at Constantinople, in Sicily, and in the south of France; but hitherto I have found no reliable notices of migrants being observed at this time in northern countries. They again showed up in the period between 1842 and 1849; for in 1843 we hear of flights of locusts in northern India, and two years after of their becoming a plague in Algeria. In 1844, *P. migratorius* multiplies in southern Russia, passing the same year in bands to Switzerland and Belgium, stragglers reaching to North Germany and the shores of the Baltic, and even penetrating into Sweden. Over this area they continue to appear until 1847, and in 1846 numerous flocks of locusts are seen or recorded in the south and north of England, in Scotland, about Aberdeen, and in the Shetland Islands, a few examples being likewise taken on the east coast the succeeding year. In 1848, *P. migratorius* continues to turn up in France and Belgium, and locusts are plentiful at Herne Bay; and the next year even we still find records of captures being made around Paris and in Belgium, and one example is taken at Thrisk, in Yorkshire.

After this memorable period we hear nothing of locusts in Europe until 1857, from which year until 1862 they continued to appear in the central and northern countries of Europe. In the year 1857 locusts were already noxious at Odessa and in China; and in 1860 we have official reports of the entry of *P. migratorius* into Bessarabia, Podolia, and Volkynia, on the southern boundaries of Poland, coming, as would seem, from Galicia, which province of Austria it may have reached from Odessa, as in 1828. However, three years previous to this it has been taken near Paris, in Belgium, and in Holland; and at the same time it visited the north of England and Ireland. In England it is recorded until 1859, and near Paris and in Belgium it is found until 1862. We likewise hear of its occurring at Malta in 1861. The next period is from 1864 until 1869. In the first-mentioned year a fresh species of locust, *Acridium peregrinum*, multiplies in Algeria, and an erratic flock of the same comes in the autumn to the coast of Cornwall. On the 2d of November of the year following, another flock of this same species boards a vessel on her voyage from Bordeaux to New Orleans 1,200 miles from land. In 1866 these locusts have increased to such an extent in Algeria that they there became a plague, and at the same time they are noticed in Corfu. They again come to Cornwall in 1869, and the same

autumn another species, as is thought, invades the coast about Aberdeen, in Scotland. During this series of years locusts multiply in Persia and in the Punjâb. The next period, occurring from 1874 until 1879, is marked by flights of *Pachytylus cinerascens* Fab., a species which, as has been ascertained, propagates in Europe, and that even as far north as Belgium, and which is not, therefore, truly an extraneous migrant. This locust is reported from Cheddar, in Somersetshire, in 1874, and the succeeding year we hear of its being destructive near the Lake of Constance, while a few more examples turn up in England, this time in Yorkshire. *Caloptenus italicus* is simultaneously destructive in France and Spain, and during the year 1876 large masses of both locusts appear at Eberwalde. The year succeeding, *P. cinerascens* again appears in greater numbers in Yorkshire. Lastly, as late as 1879 we find that locusts are still numerous in Southern Russia and Caucasia. These latter periods, as the former, may severally be compared with the sun-spot cycles, and their dependence on the minimum epochs will become manifest; they indicate a mean of about 6 years as the probable duration of the locust flights in Europe.

That certain insects besides locusts are subject to periodical increase in Europe has long ago been pointed out in the Transactions of the Zoologisch-Botanischer Verein in Wien (1855, Bd. 5), where the writer directs the attention of entomologists to the chronical increase of certain Lepidoptera, *C. Cardui*, *A. Cratægi*, *C. Edusa*, *D. Galii*, *S. Convolvuli* and *A. Atropos*, *B. Processionea*, *B. Pinivora*, and *Charæas Graminis;* to the increase of many *Libellulæ* and *Ephemeræ* among the Neuroptera, to that of the *Coccinellæ* among the Coleoptera, and that of the *Chironomi*, *Sciaræ*, and *Diploses*[16] among the fly kind. This increase the writer fancied might recur in periods of many years; but he states that at that time sufficient evidence in most cases was wanting. He, however, in the context, would seem to refer the phenomenon to meteorological causes, and in this matter he has been followed by other commentators. For instance, Mr. Stainton, in England, remarks, in the Entomologist's Annual for 1859:

> The almost unprecedented heat of last June, coming so closely on the heels of the unusually hot summer of 1857, has had a most extraordinary effect on insect life (1858). Many species that are usually rare have been taken in some plenty; species that are generally limited to a few of our southern counties have wandered far north, and some South European species not previously added to our lists have now found a place there.

Dr. Knaggs, in the Annual for 1864, draws another meteorological parallel, and says:

> If we look back we shall find that the notably severe winters which terminated the years of 1824, 1834, 1844, 1854—those of 1794 and 1814 were also intense—were followed by seasons remarkably good for collecting.

Three of these years follow on the minimum years of sun-spots.

[16] Several distinct species of Tipula are probably here indicated; Kirby and Spence, Intro., pp. 91–92, Ed. 7; Stettin Ent. Zeit., S. 65–96; Trans. Ent. Soc. London, 1881, p. 605.

TABLE 2.—*Numerical abstract of the capture of certain rare Lepidoptera in the United Kingdom.*

[From the Magazine of Natural History, Zoologist, Entomological Magazine, Entomologist, the Entomologist's Weekly Intelligencer, and the Entomologist's Monthly Magazine, &c.]

		Vanessa Antiopa.	Argynnis Lathonia.	Pieris Daplidice.	Colias Hyale.	Colias Edusa.	Sphinx Convolvuli.	Deilephila Livornica.	Deilephila Galii.	Chœrocampa Celerio.	Chœrocampa Nerii.	Deiopeia Pulchella.	Sterrha sacraria.
	1830				5	2							
	1				1	10		1*a*	1				
	2	1*s*			38						1–*lar.*		
m	3	5 ?			20	15			1		2		
	4	3*a*	4*a*		4	20	1		12	1*a*	10 ?		
	5	2*a*		3*a*	107	7	2		6 *lar.*				
	6		1	1		23							
M	7	1*a*	12 ?										
	8					1							
	9					26							
	1840					3							
	1					7	1						
	2	2*a*	4	4*a*	66	13	4						
m	3				20	202		1					
	4		1*a*		35	214							
	5	1*a*			1	76	1						
	6	38*a*	5*a*			20	583–*lar.*	16*s*	2				
	7	1*s*–3*a*	3		1	59	2						
M	8	1*s*			3	29						1	
	9				5	344							
	1850					1*s*–10				1*a*			
	1				5	1							
	2	9*a*		1*a*		7				3*a*	*lar.*		
	3				1		1						
	4		1						1				
m	5	1*s*-1*a*			16	14			*lar.*				
	6	1*s*	1*a*		11	2	20		1–*lar.*		5		
	7	5*a*	8*a*	3*a*	31	326	8		5–*lar.*		2		
	8	28*a*	10*a*	5*a*	45	13*s*–514	119	1	4–3 *lar.*				1
	9	2*s*	2*a*	7*a*	35	3*s*–454	160–*lar.*		13–220 *lar.*	2	2 *lar.*		4
M	1860				2	2	10–*lar.*	13*s*–7*a*	3	10*a*	*lar.*		
	1	1				27	3						

TABLE 2.—*Numerical abstract of the capture of certain rare Lepidoptera in the United Kingdom*—Continued.

		Vanessa Antiopa.	Argynnis Lathonia.	Pieris Daplidice.	Colias Hyale.	Colias Edusa.	Sphinx Convolvuli.	Deilephila Livornica.	Deilephila Galii.	Chærocampa Celerio.	Chærocampa Nerii.	Deiopeia Pulchella.	Sterrha sacraria.
	1862	......	......	......	......	5	5	8*s*	3–*lar.*	......	1	......	......
	3	......	......	......	......	......	1	1*s*	1	1*s*–4*a*	......	......	......
	4	......	1*a*	......	......	......	1?	......	1	......	......	......	1
	5	2*a*	12*a*	......	4	107	1	2–*bred*	*bred*	20*a*–5 *lar*	......	......	9–*lar.*
	6	......	......	......	......	3*s*–36	1	......	......	1*a*	......	......	......
m	7	......	......	1*a*	2	1*s*–20	1	10*s*–*bred*	......	15	1	......	30
	8	12*a*	66*a*	6*a*	999	87	142	23–*bred*	1	14*a*	2	......	......
	9	......	......	......	1	10*s*–7	5?	4	*lar* ?	1 *lar*	1	2*a*	4
M	1870	3*a*	1	2	1	1*s*–30	2	23*a*–7 *lar*	32–13 *lar*	3*a*	......	1*s*	......
	1	2	1	8*a*	......	......	10	......	12 *bred*–*lar*	1*a*	......	28*a*	2
	2	1*s*–300*a*	60*a*–1*s*	3*a*	22	36	2–*lar.*	2	......	4*a*	......	......	1
	3	9*s*–11*a*	......	......	......	......	4	......	......	5?	1	......	......
	4	......	......	......	......	1	......	......	......	......	......	1*s*–14*a*	......
	5	9*a*	......	......	60	54	157	......	......	1*s*–2*a*	......	16*a*	......
m	6	7*a*	1*a*	2*a*	5	5*s*–26	6	......	1	2*a*	1	21*a*	......
	7	8*a*	......	1*s*	5	359*s*–3683	6–1 *lar.*	1	......	2*a*–1 *lar*	......	......	2
	8	2*s*–1*a*	......	......	1	8*s*–33	3	2	......	1*s*–2*a*	......	?	......
	9	......	......	......	......	5*s*–332	......	5	......	1*a*	......	......	......
	1880	49*a*	18*a*	......	......	......	......	1	......	6*a*	......	1*a*	......
M	1	3*s*–1*a*	1*a*	......	......	8	18	......	......	3	......	3*a*	......

ABBREVIATIONS EMPLOYED: *a*, Autumn; *s*, Spring; *lar.*, larvæ or caterpillars; *bred*, the species bred or reared in the United Kingdom; *m*, years of fewest sun-spots; M, years of most sun-spots.

My second table (Table II) is drawn up so as to illustrate this subject, and it will show how the phenomena of multiplication and migration of European Lepidoptera may be correlated with the sun-spot cycles. It refers to the periodical occurrence of certain rare moths and butterflies in the United Kingdom, which, from their persistent first appearance on our eastern and southeastern seaboard, are very generally supposed by entomologists to be migrants to this country. It has been also surmised that these come to us as the vanguard of a great and well-defined migration of insects that periodically sweeps over the European area, originating, as in the case of locust invasions, if we judge from the localities of observation and description of the species, in Africa or southern Asia. In constructing this table, I have selected a dozen of these rarities whose fitful appearance in this kingdom has been sufficiently chronicled to afford me certain results, and I have given a numerical abstract of the records relating to their capture, from the Magazine of Natural History, Zoologist, Entomological Magazine, Entomologist, the Entomologist's Weekly Intelligencer, and the Entomologist's Monthly Magazine. I have likewise found it proper to consult the Naturalist, Newman's British Butterflies, and other works.

The plan I have followed is in all cases to give the number of each kind of moth or butterfly captured or seen during a particular year, but in the instance of the commonplace Clouded Yellow (*C. Edusa*), where scarcity or frequency is alone a subject of comment with our entomologists, something more was needed, and to meet this emergency I have, over and above, adopted an arbitrary method of placing a 5 for every notice of the butterfly being plentiful, a 10 for every notice of its being common, and a 20 for every notice of its being abundant. In this way I have arrived at a series of numbers, which, if they fail in every case to translate the exact meaning of the writer, will nevertheless to all intents and purposes serve truly and concisely to indicate the fluctuation of the species. In addition to this, it has seemed of importance to indicate the period of the year when the captures were made, and to this end I have affixed an *s*, spring, or an *a*, autumn, to the numbers; or, in the case of the hawk moths, I have placed the contraction *lar.*, and word *bred*, with a numerical figure to show the number of caterpillars of a species found or bred in this country in such and such a year. The solar cycles are indicated in the first column, the epochs of fewest sun-spots being marked with a small *m*, and those of most sun-spots being denoted by a capital M.

It will be then noticed that the periods of influx, although marked in the table as commencing with the epoch of minimum spots, are, as in the instance of European locust invasions, protracted until the ensuing maximum, on the expiration of which a sudden diminution in the number of rarities noticed is manifest. As many of these, and the hawk moths in particular, have their home on the borders of the tropics, it is

probable that in this case, likewise, the epoch of fewest spots is their season of increase, and that during the ensuing years a tide of migration sets in northward. Thus we read in the transactions of the French Entomological Society that in 1834 the south wind was very violent at Montpellier[19], and brought *Chærocampa Celerio* and *Deilephila Lineata*, alias *Livornica*, in great numbers from Africa; and subsequently the first of these moths, with *Chærocampa Nerii*, which became common in 1835, occurred on the continent until 1839 or thereabouts. The next migration, a remarkable one, took form in Germany in 1842, and in 1846 the rare hawk moths, *Convolvuli*, *Livornica*, *Celerio*, and *Nerii*, oviposited over the whole of western Europe, *Celerio* reaching as far north as Stralsund. After this date, *C. Nerii* was noticed in France during the years 1856–'57, and at the same time it was likewise found in England.[20] It is also to be remarked that the year 1874[21] brought suddenly a rare satellite of the hawk moths, *Deiopeia Pulchella*, to the notice of Parisian entomologists, and in the following two years this southern and eastern insect occurred in France and England.

Certain periods likewise may be considered to have brought certain lepidopterous species to England. Thus 1846 was a great *Convolvuli* year, 1870 a great *Livornica* year, and 1877 a great *Edusa* year. Yet, although these rare visitants duly oviposited and often bred in this country, a glance at the table shows that they were virtually eradicated from it during the subsequent unfavorable years. It would appear, however, that a temporary colony may result from these flights, as in the case of *Chærocampa Nerii*, which propagated in a garden in Berlin between the years 1829 and 1832;[22] that of *Deilephila Euphorbiæ*, which, discovered at Braunton Burrows, near Ilfracombe, in 1806, became abundant in the larva state in that part of Devonshire about 1819–'20;[23] and that of *Deilephila Galii*, which bred on the sand-hills at Deal, between 1855 and 1862.[24]

With regard to the quarter whence the arrivals of rare butterflies come to us, and their distribution, Mr. Stainton has stated in the Entomologist's Monthly Magazine (Vol. VII, p. 105[25]) "that *Pieris Daplidice*

[19] Trans. Soc. Ent. de France, Tom. V, p. 365. Other works from whence the following abstract is drawn: Stettin Ent. Zeit.; Soc. Ent. de Belgique; Wiener Ent. Monatschrift; Nederlands. Ent. Vereen., Tijds. voor Ent.; Ent. Nachrichten. There is a want of field record on the continent, and I am afraid the prejudice has crept into this country of late years.

[20] Convolvuli everywhere in the autumn of 1858 and 1859. Nederlands. Ent. Vereen, Tijds., voor Ent.

[21] Convolvuli plentiful at Gratz, Rugen, Nassau, and Sachsen, Aug. and Sept., 1875. Ent. Nachrichten.

[22] (Stettin Ent. Zeitung, viii, S. 132.) Herr Bouché's notice: Ich selbst habe sie (Nerii) in den Jahren 1829 bis 1832, jährlich in meinem Garten theils als Raupe theils als Schmetterling gefangen. . . . Frisch war wohl der Erste in Deutschland, der ihn beschrieb. Er berichtet im VII Theile p. 5 seiner "Beschreibung von allerley Insekten" es sei der Sommer von 1727, in welchem sich diese Raupenart auf den meisten Oleanderbäumen gefunden habe, sehr trocken gewesen. Rösel in 3ten Theile seiner "Insektenbelustigungen" notices the occurrence of Nerii in 1740.

[23] Entomological Magazine for 1834. Mr. Raddon says: No Euphorbiæ were obtained after 1819 until the 3d of October, 1834, when a single chrysalis was found; they were exceedingly plentiful in 1814 (100 larvæ on a piece of spurge) and 1815 (20 pupæ obtained).

[24] Entomologist's Monthly Magazine, Vol. II, p. 5–8.

[25] Also, Trans. Ent. Soc. London, new series, Vol. V, p. 234.

and *Argynnis Lathonia* seem confined to the southern counties of England, not ranging north of Peterborough, but that *Vanessa Antiopa* is most plentiful between the Humber and the Tyne." From this the writer would infer "that if *Daplidice* and *Lathonia* come to us from France, *Antiopa* more probably comes from Norway. I believe there is much in this argument, and I surmise the 'Camberwell Beauties' may come to us semi-torpid with deals from Norway." It still, however, should be noticed that twelve years out of thirty that this butterfly has been taken the records appertain solely to the southern counties, and that in 1873 and 1874, years succeeding a great migration, it was plentiful enough in parts of France and North Germany. In 1842, a year when *Daplidice* was taken near Dover, several examples were found simultaneously in Belgium,[26] a country where it generally occurs but singly. *Lathonia* again was frequently seen in Jersey from 1870 until 1872;[27] a circumstance which seems to afford a reason for connecting in a series the captures made in this country during that period. As regards distribution: in 1858, 1872–'73, and, as is stated, in 1861, *Antopia* visited the east of Scotland, and in 1865, 1872, and 1875 it was taken in Ireland. During the years 1847, 1852, 1857, 1862, and 1877 *Edusa* was taken in Scotland, and in 1844, 1865, and 1877 it was seen in Ireland. Generally, however, the Clouded Yellow is confined to the southeast coast of England, where I am not sure that it occurs every year. *Hyale* has been taken in Ireland, but it seems to have pushed no farther north than Northumberland, where it was captured in 1834.

In conclusion, it may be asked, "Can any one say when the locusts will again leave their breeding grounds and ravage the cultivated land?" To this question I think a ready answer may be given. "Towards the next period of fewest sun-spots and earthquake prevalence, which will occur, it may be four, it may be ten years hence." Again, it may be asked, "Tell us if the ordinance of the *sun-stars* in their courses is at present for or against their increase." To this question my data do not enable me to directly reply. It has been said by one writer that the locusts multiplied at the time Europe was visited by the black death (1333–1359), the sweating sickness (1551–1553), and the plague of Barbary (1799–1800), which severally indicated sun periods when epidemics spread northward. For, taking out the great cycles of east and west deviation of the magnetic compass as uniform (1814 W.—1580 E.—1346 W.),[28] syn-

---

[26] Soc. Ent. de Belgique. An., tom. 1–4.

[27] Entomologist for 1872, two taken in the little island of Sark in 1872, but this is perhaps nothing unusual; in 1876 I noticed a few near Calais.

[28] Tables showing the east and west variation of the magnetic needle are given by Sir David Brewster in his Treatise on Magnetism. The cycles are given as from 1580 maximum east deviation, to 1815 maximum west deviation at London; 1580 maximum east deviation, to 1814 maximum west deviation at Paris; and the maximum west deviation at the Cape of Good Hope is stated to have occurred in 1791, that is, thirteen years earlier. He adds: "Professor Hansteen has explained these progressive changes in the variation of the needle by the motion of the four magnetic poles. Taking the variations at Paris for the northern hemisphere, he remarks that in 1580 the weak N. pole in Siberia was about [illegible]° E. of Greenwich, or to the N. of the White Sea; while the strong American pole was about

chronism may be argued in favor of the occurrence of the plague of Barbary, the sweating sickness, and we may say of the black death. Yet with none of these disastrous positions on the great cycle does the present time agree. If the sun-spot cycles be examined, it will be further seen that we have reached a time when the solar phases are short, and that similar short phases are given by the seismic data as having transpired about the middle of the seventeenth century, and again, as would seem from observed sun cycles, about the middle of the eighteenth. Although the agreement is not exact as regards figures, we still discover that the points are marked by the freezing of the Thames, plainly indicating the passage of intensely cold winters (1670 and 1683–'4), especially in the former case, where there is just previously a change indicated in the frequency of auroral displays (about 1640), that is almost synchronous with the great plague of London (1648–1665). Two great locust swarms in their sweep over Europe mark the intermediate period of time, namely, those of 1689 and 1747, but whether any exact agreement may exist between the epochs of these visitations of Providence I cannot say. They seem to indicate fragments of climatic cycles and attendant phenomena, following the greater sun-periods marked by the east and west deviation of the compass needle, and corresponding to those we have established for the minor. If we may further suppose the changes of climate that have transpired between 1346 and 1580 to have been similar to those that have been experienced since the year 1814, we might, in picturing to ourselves the multiplication of *C. spretus* during the period 1845–1877, call up before the mind's eye the production of that great swarm of grasshoppers that invaded Europe about the years 1353 and 1374. Both points of time, to say the least, must have been pretty well identically marked by the point of the compass needle on its circuit.

In concluding my essay, in order to assert the noble dignity of my subject, in order to free myself from all calumny from those of my brother naturalists untrained to numerical computation, or from imputation of the black art on the part of those little thinkers who might

---

136° W. of Greenwich, or 36° E. of Behring's Straits. The weak pole, therefore, lay nearer Europe than now, and the strong one more remote. Hence the action of the former predominated, and the needle turned westward till 1814, in which year it reached its greatest declination, and commenced its easterly course." The explanation is equally satisfactory in reference to the southern hemisphere, and the variation at the Cape, where in 1605 the weak S. pole was 76½° W. of Greenwich, and the strong S. pole about 150° E. of that meridian. The two northern and two southern poles are elsewhere supposed by Sir David Brewster to be the points of greatest cold, while a marked agreement exists between the magnetic (isodynamic) and mean temperature (isothermal) lines.

James Forbes (Math. and Phys. Science, p. 990) says, speaking of the charts of Halley and Hansteen: "It results from these charts that the line of no variation, which in 1600 formed a remarkable arch-like curve, stretching from the Gulf of Mexico to near the North Cape of Norway, then descending through Central Europe to the Gulf of Guinea, had, during the seventeenth and eighteenth centuries, become gradually flattened (having passed through Paris in 1669, and through London twelve years earlier), and at present this part of the line of no variation is confined to the American continent and neighboring seas. Another and more complicated branch of the same line traverses the Pacific Ocean, making a complex serpentine track through Eastern Asia and Siberia. The line of no variation may be expected to pass through those points of the earth's surface towards which the needle converges."

hastily conclude that I had bound up their destinies in a sun god, with clear conscience, I challenge academical support for the following enunciation, arising out of a study of my subject: The weather is the cause of insect multiplication; the weather in consecutive years differs alone (virtually) on account of changes in the sun's photosphere. Isolated observations on temperature, magnetic deviation, auroras, wind disturbance, rainfall, water in rivers, famines, diseases, or epidemics, earthquakes, and other sun phenomena give erroneous results. Properly generalized observations show almost invariably an exact concordance between the *sun changes* and these *effects*. The conception, as the proof, is one of numbers.

PART II.

THE ARMY WORM, CANKER WORMS,

AND

THE HESSIAN FLY.

CHAPTER VI.

THE ARMY WORM (*Leucania unipuncta* Haw.).

[Plates I and II.]

NOMENCLATURE.

There is perhaps on this side of the Atlantic no more familiar insect name than that of Army Worm. Unfortunately, however, this name is as comprehensive as are most popular names, and, as used by different people, in different parts of the country, may refer to entirely different insects. In fact, in but few other cases is this bane of popular entomology—the application of a limited number of popular names to an almost unlimited number of insects—better exemplified than here.

Years ago some unwise individual applied the title Army Worm to the southern Cotton Worm (*Aletia xylina*, Say). Glover adopted the title, prefixing, however, the word *cotton;* but it has occasioned confusion ever since. For instance, there appeared in the columns of one of our prominent agricultural periodicals, during the disastrous Army Worm year of 1861, an article, couched in pseudo-scientific language, stating that the insect ravaging the New England fields was the *Anomis xylina* of Say, quoting from a Louisiana paper an account of its work in the southern cotton-fields, and following with an article from some western periodical describing its injuries in the wheat-fields of the Northwest.

Another southern insect, the Grass Worm (*Laphygma frugiperda*, Sm. & Abb.), has been dubbed "the Army Worm" by southern people, and this name for this species was adopted by Lyman in his Cotton Culture, and by others; hence a confusion between these two insects also has always existed, though here the mistake is more excusable, owing to their great resemblance in the larva state, both in appearance and habit.

The Tent caterpillar of the forest (*Clisiocampa silvatica* Harr.) often appears in extraordinary numbers, especially in the Southern States, where large stretches of oak forest are sometimes defoliated by it, and when migrating in search of suitable places to spin up, or when seeking further food, it has been called "the Army Worm." We have previously cited[29] its appearance near Memphis in 1872, when it frequently stopped the trains going in and out of the city. It stripped orchards, and great lanes of bare trees marked its track through the woods.

At a meeting of the Western New York Fruit-Growers' Association, in 1861, there was a learned discussion of the "Army Worm" and the

[29] 8th Missouri Entomological Report, p. 23.

means necessary to prevent its injuries to fruit trees. Although the subject was discussed by a half dozen or more practical horticulturists, no one corrected the name, and all spoke gravely of shaking them from the tree, or of belting it with lard and sulphur or other mixture to prevent the worms from climbing up. Possibly this name answered their purpose sufficiently well, as all were evidently speaking of the same insect—probably the Canker Worm—but think of how the discussion was quoted in one paper and another, and think of the confusion which the reading of such a report would create in the minds of those anxious to learn the truth, and who had not access to reliable works!

The California newspapers have from time to time recorded the appearance of the Army Worm in that State. That the genuine Army Worm is not concerned in this damage is shown by the fact that the insect, whatever it is, has manifested little disposition to injure the grain; but garden vegetables, and even grapes, have suffered severely from its attacks.

The larvæ of Sciara, which congregate together in large numbers and move as one body, attached to one another, head and tail, are called by our German citizens "the Army Worm" (*Heerwurm*).

In Europe several larvæ are known by this name, particularly the *Calocampa exoleta* (Linn.).

The Army Worm proper, which we have sometimes called the Northern Army Worm to better distinguish it,[30] and which was known in the early chronicles as "the Black Worm," is the larva of a Noctuid moth, known as *Leucania unipuncta* (Haworth).

The history of its synonymy is as follows: Upon the breaking up of the collection of Dr. Francillon, in London, a specimen of this moth, without locality label, fell into the hands of Mr. Haworth, who in 1810 described it in his Lepidoptera Britannica as *Noctua unipuncta.*

In 1829, Stephens, in his Illustrations of British Entomology, Haustellata, III, p. 80, published a description of it, under the name of *Noctua impuncta*—either a misprint or a slip of the pen—and stated that its habitat was unknown.

In 1850 (List of the Lepidoptera in the British Museum, p. 289), the same author corrected his previous mistake in the specific name, and stated the insect to be North American. In 1852, Guenée, in the first part of his Noctuélites, pp. 77, 78, described the species as *Leucania extranea*, not having connected it with Haworth's species. He described it from numerous exotic specimens in Parisian collections.

[30] Though the insect prevails in the South, yet in the Cotton States it rarely if ever attracts the same attention as in the more northern States. This is due, in our judgment, to the following facts:—

1st. The species, both in the larva and imago states, is more continuously active through the winter, and consequently more subject to destruction by birds and other natural enemies.

2d. The area of grain and grass crops, upon which it feeds, is limited, as compared with cotton, upon which it does not feed.

Of late years, a few American Lepidopterists, following Mr. A. R. Grote, have adopted Hübner's generic name of *Heliophila* in place of *Leucania*. We would repeat here Mr. Riley's reasons for rejecting this and other of Hübner's "coitus" names for modern genera.

I consider that the reasons so long urged by entomologists against the adoption of the classification of the "Tentamen" and "Verzeichniss," and particularly those given by Guenée, for not following this last in his admirable work on the Noctuidæ, are good and sound. The Hübnerian classification is essentially unreal and the generic divisions so inadequately defined that I doubt if any one would attempt to make use of the works in question, were it not for the references to the admirably illustrated works of the same author. The introduction of his generic terms into American Lepidopterology has so upset its nomenclature, without in the least advancing our knowledge, and the grounds for this introduction are so questionable, that those who make these insects a specialty are apt in the future to divide into two factions—the Hübnerites and the anti-Hübnerites; in which event the latter will certainly have strong support from entomologists in general.—[8th Mo. Ent. Rep., p. 22.

GEOGRAPHICAL DISTRIBUTION.

Leucania unipuncta is a very widespread, we may say cosmopolitan, species, though nowhere, as far as we are aware, is it particularly noted as an injurious insect except in the United States. On this continent its range is great. Packard's map (Report on Rocky Mountain Locusts, &c.) gives its southern limit as the southernmost point of Texas; its western limit at 102° west; north at parallel 48° in Minnesota and at Cape Rozier in Quebec, and east at the easternmost point of Nova Scotia. We have no data as to a wider range except that in the British Museum catalogue of lepidoptera this species is entered as from "the west coast of North America." Without much doubt, however, it will be found farther west and farther north than the limits we have mentioned, as collections from out of the way spots become more common. The regions most ravaged, as taken from Packard's map, are as follows: Eastern Iowa, Southern and Central Wisconsin, excluding an eastern strip; Northwestern, Southern, and Central Illinois; Eastern Kansas, Eastern Missouri, Southwestern and Southeastern Indiana, Northern Kentucky, the whole of Ohio, Eastern and Western Pennsylvania, Eastern and Southern New York, Western New Jersey, the whole of New England, except a small western strip of Massachusetts and Connecticut, and the northwestern half of Vermont.

The species has not been found, so far as we know, in the West Indies, though we certainly think that it exists there. Both Guenée and Walker mention it from various parts of South America—Venezuela, United States of Colombia, and Brazil. In Europe it has been recorded from the Isle of Wight, and from Lewes, South England. Farther east the moth has been captured in the Province of Nepaul, North India, in Java, in several localities in Australia, and, to end our list, in New Zealand.

CAPACITY FOR INJURY.

It seems strange, indeed, that *Leucania unipuncta*, widespread as it is, should be destructive only in the more northern of the United States; yet such seems to be the case, so far as we have any facts to warrant conclusions. Here, however, the capacity for injury is very great. Hardly a year passes by without its appearance in some part of this area, and a resulting damage to crops of hundreds of thousands of dollars. Its high rank as an injurious insect is so well known that, in the absence of definite statistics as to losses, it seems hardly worth dwelling upon. In fact the only case in which statistics have been attempted is the estimate of damage to western Massachusetts in 1861, where it was placed at half a million of dollars, and, as there were twenty States damaged to a greater or less extent this same year, the total loss for 1861 could not be far from $10,000,000.

The injury to crops in 1861 was, however, as we shall soon show, more widespread than in any preceding or succeeding year; yet even in years of local appearance the injury is sometimes very great. Last year (1881), for instance, the amount of damage done to a single crop (oats) in Illinois and Indiana was not far from three-quarters of a million dollars. The magnitude of the interests involved causes even a slight percentage of loss to represent a very large sum. This is readily shown by the fact that in 1880 the value of those crops subject to the ravages of *Leucania* amounted to over one billion seven hundred millions.

PAST HISTORY.

In 1854 Charles L. Flint compiled, for the report of the Secretary of the State Board of Agriculture of Massachusetts, "an account of the meteorology of the New England States with reference to the years of drought from 1623 on to the date of writing." In this account appear incidentally the following notices of worms, which may possibly refer to Leucania:

1632. "The worms made extensive ravages on the corn."

1646 and 1649 "were caterpillar years."

1666. "The Indian corn eaten by the worms."

1743. "Millions of devouring worms in armies, threatening to cut off every green thing."

1762. "At last, when the corn was planted, millions of worms appeared to eat it up."

1770. "A very uncommon sort of a worm, called the Canker Worm, ate the corn and grass all as they went above ground, which cut short the crops in many places."

Of these entries that of 1743 is the only one which has been quoted as a genuine Army Worm reference; it is indeed always mentioned as the first Army Worm year. But we must not overlook the fact that while the entries of 1632 and 1666 may refer to *Heliothis armigera*, those of

1646 and 1649 to any one of many species, and that of 1762 to some cut-worm, yet they may also, one or all, very possibly refer to Leucania. For exact purposes, however, we may agree with Fitch and the others who have followed him so closely, in considering 1743 as the first Army Worm year of which we have pretty definite proof. We are also inclined to think that Flint's quotation in regard to 1762 has reference to Leucania, though not as certainly as that of 1743.

Concerning the appearance of the Army Worm in 1770 there can be but little doubt, for, in addition to the quotation given above, we have two graphic accounts which quite evidently point to the true Army Worm as the author of the damage. The first is that given by the Rev. Grant Powers, in his Historical Sketches of the Coös Country (New Hampshire), published at Haverhill, N. H., in 1841:

In the summer of 1770 this whole section was visited by an extraordinary calamity, such a one as the country never experienced before or since, beyond what I shall here specify. It was an army of worms, which extended from Lancaster, N. H., to Northfield, in Massachusetts. They began to appear the latter part of July, 1770, and continued their ravages until September. The inhabitants denominated them the "Northern Army," as they seemed to advance from the north or northwest and to pass east and south, although I do not learn that they ever passed the high lands between the Connecticut and Merrimack Rivers. They were altogether too innumerable for multitude. Dr. Burton, of Thetfort, Vt., told me that he had seen whole pastures so covered that he could not put down his finger in a single spot without placing it upon a worm. He said he had seen more than ten bushels in a heap. They were unlike anything which the present generation have ever seen! There was a stripe upon the back like black velvet, on either side a yellow stripe from end to end, and the rest of the body was brown. They were sometimes seen not larger than a pin, but in their maturity they were as long as a man's finger and proportionably large in circumference. They appeared to be in great haste, except when they halted to devour their food. They filled the houses of the inhabitants, and entered their kneading-troughs, as did the frogs in Egypt. They would go up the side of a house, and over it, in such a compact column that nothing of the boards or shingles could be seen! They did not take hold of the pumpkin vine, pease, potatoes, or flax; but wheat and corn disappeared before as if by magic. They would climb up stalks of wheat, eat off the stalk just below the head, and almost as soon as the head had fallen upon the ground it was devoured. To prevent this the men would "draw the rope," as they termed it; that is, two men would take a rope, one at each end, and pulling from each other until it was nearly straightened, they would pass through their wheat-fields and brush off the worms from the stalks, and by perpetual action they retarded the destruction of their wheat; but it was doomed, finally, to extinction.

There were fields of corn on the meadows in Haverhill and Newbury, standing so thick, large, and tall that in some instances it was difficult to see a man standing more than one rod in the field from the outermost row; but in ten days from the first appearance of this Northern Army nothing remained of this corn but the bare stalks! Every expedient was resorted to by the inhabitants to protect their fields of corn, but all in vain. In the first place they dug trenches around their fields a foot and a half deep, hoping this might prove a defense; but they soon filled the ditch, and the millions that were in the rear went over on the backs of their fellows in the trench and took possession of the interdicted food.

The inhabitants then adopted another expedient to save those fields yet standing. They cut a trench as before; then took round and smooth sapling sticks, of 6 or 8 inches diameter and 6 or 8 feet in length, sharpened them to a point, and with these made holes in the bottom of the ditch, once in 2 or 3 feet; and, as their meadows

were bottom lands, they experienced no difficulty in extending these holes to 2 or 3 feet in depth below the bottom of the trench. The sides of these holes were made smooth by the bar or lever which made the holes, and as soon as the worm stepped from the precipice he ended at the bottom, and could not ascend again; indeed, he was soon buried by his unfortunate fellows who succeeded him in his downfall. Now those who made these holes to entrap their invaders went around their fields and plunged these pointed levers into the holes filled with worms, and destroyed every one of them at a single thrust, whether it was a peck or a half bushel. By unremitting effort in this way, some reserved to themselves corn enough for seed the next year.

About the 1st of September the worms suddenly disappeared; and where they terminated their earthly career is unknown, for not the carcass of a worm was seen. In just eleven years afterward, in 1781, the same kind of worm appeared again, and the fears of the people were much excited; but they were comparatively few in number, and no one of the kind has ever been seen since.

He then goes on to say that if it had not been for the pumpkins, which thrived marvelously in the corn-fields after the grain had been destroyed by the worms, many people would have died the ensuing winter from the scarcity of food consequent upon the ravages of the worms. The extraordinary abundance of wild pigeons also helped to sustain many who otherwise would have perished.

The account which Fitch quotes from Noah Webster on Pestilential Diseases (I, 259) may here be given, as it presents one or two points of difference from Powers's account, which are italicized.

In 1770 a black worm *about an inch and a half long* devoured the grass and corn. Never was a more singular phenomenon. These animals were generated suddenly in the Northern States of America, and almost covered two or three hundred miles of country. They all moved nearly in one direction, and when they were intercepted by furrows in ploughed land they fell into them in such numbers as to form heaps. *They sought shelter in the grass, a hot sun being fatal to them.* They disappeared suddenly about the close of June or beginning of July.

From Powers's description of the worm alone much doubt might exist as to its identity with Leucania. Indeed it applies much more closely to a large sphinx larva, the *Deilephila lineata*, Fabr. It may, however, have been written some years afterwards, the size of the worms having become magnified in the memory of the writer, and the other details confused. Webster, as is seen in the above quotation, gives more nearly the correct size, and, all things considered, the worm was most probably the true Army Worm.

In 1790 Webster again records their appearance, this time in Connecticut, as follows:

In 1790 millions of the black worms noticed in 1770 reappeared in Connecticut, appearing at Hartford and Norwich, and disappearing in these places at the same time. They were very destructive to the grass and corn, but their existence was short, all dying in a few weeks.

In 1817 the worms again appeared in Massachusetts, New York, and other parts of the country. Fitch quotes from the Albany Argus as follows:

Worcester, May 22.—We learn that the *black worm* is making great ravages on some farms in this town, and in many other places in this part of the country. Their march

is a displayed column, and their progress is as distinctly marked as the course of a fire which has overrun the herbage in a dry pasture. Not a blade of grass is left standing in their rear. From the appearance of the worm, it is supposed to be the same which usually infests gardens, and is commonly called the cut-worm. We are informed that about forty years ago the same kind of worm made great destruction in ploughed land, among spring grain, but particularly in fields of flax.

The Albany Argus adds to the above as follows:

This black worm is also destroying the vegetation in the northern towns of Rensselaer and eastern sections of Saratoga. Many meadows and pastures have been rendered by their depredations as barren as a heath. It appears to be the same species of worm that has created so much alarm in Worcester County, but we suspect it is different from the cut-worm, whose ravages appear to be confined to corn.

In 1818 or 1820 the worm appeared in large numbers in Union County, Illinois, as Walsh was informed by one of his correspondents.

1825.—In this year the worms damaged the timothy crop in parts of Ohio, as appears from an article by Jos. Bradshaw in the Farmer's Reporter (Ohio), 1835, copied in the American Farmer's Register of the same year. They also appeared this year in Perry County, Illinois, according to Walsh.

1826.—Damaged the crops in Perry County, Illinois. (Walsh.)

1830.—Did much injury in Illinois, according to the New England Farmer of July 2, 1830.

1834.—Perry County, Illinois. (Walsh.)

1835.—According to Volume V of the Cultivator (Boston), the Army Worm this year appeared in Missouri—nineteen years earlier than the first appearance in this State, given in our Eighth Missouri Entomological Report. In this instance is mentioned for the first time the good which the worms occasionally do by stripping off the leaves affected by rust. It also damaged the timothy crop in Ohio this year, as we learn from the article of Jos. Bradshaw mentioned above. It also appeared, according to Thomas, in Vermillion County, Illinois.

1837.—Vermillion County, Indiana. (Old agricultural newspaper.)

1838.—Union County, Illinois. (Walsh.)

1839.—Perry County, Illinois. (Walsh.)

1841.—Perry County, Illinois. (Walsh.)

1842.—This was a year of more extended appearances. According to Walsh it damaged the crops of Union, Perry, and some of the northern counties of Illinois. Fitch states that it appeared this year at numerous points in Northern Illinois, and from an old number of the Country Gentleman we learn that it did some damage in Western New York.

1845.—Northern Illinois (Walsh); numerous points in Northern Illinois (Fitch).

1849.—This year it again appeared in Illinois, according to Walsh, and also in Southwest Michigan, according to the Michigan Horticulturist.

1850.—Illinois. (Walsh.)

1854.—According to the statement of Mr. M. P. Lentz, of Rocheport,

Mo., the worms abounded this year in parts of Boone County, Missouri, as stated in our Eighth Missouri Entomological Report.

1855.—This was the year in which Mr. John Kirkpatrick first studied the Army Worm. He reared the worms to the perfect state and described the larva and the moth. Their work is described as follows:

Last season (1855), in consequence of the heavy rains in the early part of June, the flats of the Cuyahoga (Northern Ohio) were flooded. After the subsidence of the water, and while the grass was yet coated with the muddy deposit, myriads of small blackish caterpillars appeared; almost every blade had its inhabitant; no animal could feed upon it without at every bite swallowing several; if a new blade sprung up it was immediately devoured; but, what was more remarkable, the insects did not attempt to remove to land a foot or two higher, but that had not been covered by the water.

1856.—Union County, Illinois.

1857.—In 1857 the worms again appeared in Union County, Illinois, and also in Maryland. A writer from the latter State gives an account of the worms in the New Jersey Farmer of that year. He describes for the first time two of the Army Worm's parasites—the one a Microgaster (probably *M. militaris* Walsh), and the other a Tachinid (probably Kirkpatrick's *Nemoræa leucaniæ*).

1858.—Illinois (Fitch); northern counties of Illinois (Walsh).

1861.—This is by far the most celebrated of the Army Worm years, because, in the first place, the worms appeared in destructive numbers over an immense extent of country, and, in the second place, because this appearance called forth the elaborate articles of Fitch, Walsh, Kirkpatrick, Thomas, Packard, and Shurtleff. Indeed, barring Kirkpatrick's short note in 1855, this was the first year in which the Army Worm had been at all scientifically studied. Its distribution this year was as follows:

It was first noticed in numbers sufficient to cause alarm in Tennessee and Kentucky during the month of April; and toward the close of the same month it appeared in the southern counties of Illinois. By the end of June it had visited nearly all portions of the latter State, proving more or less destructive to grass, wheat, oats, rye, sorghum, and corn.

Its advent in Missouri was simultaneous with that in Illinois, and, judging from what facts I have accumulated, it occurred very generally over this State, though recorded only in Saint Louis, Jefferson, Warren, Boone, Howard, and Pike Counties. No mention is made of its occurrence, at this time, in any of the States or Territories west of Missouri, but to the east scarcely a single State escaped its ravages. In many portions of Ohio it entirely destroyed the hay and grain crops. (Riley's 8th Mo. Ent. Rept.)

Along the Ohio River, in the southern part of the State, and even as far north as Shelby County, the damage was all done prior to the middle of June, while in the northern counties, bordering on Lake Erie, the worms were not observed until the 1st of August. They were prevalent in Indiana, the northern and western portions of Pennsylvania, the southern and western portions of New York, as far north as Seneca County; in all New Jersey, and throughout all New England, along the sea-coast as far as the Saint Croix River, in Maine, and as far north as Montreal, in Canada.

In 1865 and 1866 it attracted attention in restricted localities in Illinois and Missouri. In 1869 it again appeared in vast numbers in many portions of Missouri, especially in Saint Louis, Jefferson, Cooper, Callaway, Henry, Saint Clair, Marion, Ralls, and Lafayette Counties; also in Illinois and Indiana.

1870.—In this year the worms were reported to the Department from Jefferson and Crawford Counties, Kansas; Polk and Osage, Missouri, and Richland, Wisconsin.

1871.—Marion and Morgan Counties, Illinois (Prairie Farmer Record); Linn, Louisa, Washington, Appanoose, and other counties in Iowa (State Agricultural Report, 1871), and Warren County, New Jersey (Monthly Report Department of Agriculture, 1871).

1872.—In 1872 it was more widespread, and I received specimens from several correspondents, in Iowa more particularly. It was reported in Louisa, Van Buren, Wapello, Jefferson, Muscatine, Jasper, Washington, Iowa, and Adams Counties in that State, and very generally in Wisconsin, in Ohio, and in Kentucky. It attracted less attention in Illinois and Missouri, though I met with it frequently in the last-named State. It was also reported from Tioga County, New York. Graphic accounts were likewise published of its devastations in Tennessee, and the California Farmer of July 25, 1872, reported legions of Army Worms as appearing over that State spontaneously, and "stripping vines and potato fields." From this last statement I infer that they were of some species other than the one we are considering.

But the most interesting manifestation of the insect during the year 1872 was in the vicinity of Peshtigo, in the northeastern portion of Wisconsin. It will be remembered that of the memorable fires that ravaged the northwestern country in the fall of 1871, none, after that of Chicago, attracted more attention or caused more sympathy for the sufferers therefrom than that which swept through Peshtigo, destroying the whole town and causing numerous deaths and great distress. During July of the following year the people of Peshtigo suffered another infliction in the shape of armies of worms that destroyed the crops and were so numerous that in many places they could be shoveled up by bushels, and fell into wells in such myriads as to render the water foul and useless. This case has such an interesting bearing on the insect's natural history that I shall revert to it again under that head. For the present it is only necessary to say that there can be no doubt as to the species, as specimens received by Dr. Le Baron and by myself showed it to be the insect under consideration. (Riley's 8th Mo. Ent. Rept.)

In addition to these localities we have the following from the entomological records in the Monthly Reports of the Department of Agriculture: Wabash, Monroe, Lawrence, Carroll, Ogle, and White, Illinois; Cherokee and Labette, Kansas; Posey, Gibson, Spencer, Hancock, Marion, and Pike, Indiana, and Henry and Nahaska, Illinois. Also in a few localities in Rhode Island and Connecticut the sod-corn and the grass crops were taken.

1873.—This year the worms injured the grass crop in Northumberland County, Virginia, in July (undoubtedly the second brood), and they also occurred during the year in Bedford County, Tennessee, on clover; in Posey and Dubois Counties, Indiana, on meadows; and also in Edwards, Williamson, Franklin, and Perry Counties, Illinois, also on meadows.

1874.—In 1874 the worms were decidedly more injurious than in the preceding year. In Kentucky they appeared in Logan, Adair, McLean, Livingston, Breckinridge, Taylor, and Ohio Counties; in Tennessee, in Knox, Chatham, and Putnam Counties, on grass, and in Dickson County, on millet; in Missouri, in Saint Genevieve and Logan Counties, and in Illinois, in Marion, Edmunds, Jackson, and Montgomery Counties. In his Entomological Record for this year, Glover says that *Leucania unipuncta* in July damaged grass in Richland County, South Carolina, Heard County, Georgia, and Macon County, Alabama; but it seems quite likely that the insect doing the damage was the "Grass Worm" (*Laphygma frugiperda* Sm. & A.), and not Leucania.

1875.—The following account of the work of the Army Worms during the year 1875 is taken from Glover's Entomological Record, in the Monthly Reports of the Department of Agriculture for that year, page 369, and in all probability refers to *Leucania unipuncta*:

GRASS ARMY WORMS (*Leucania unipuncta* prob.).

This insect appeared in Lincoln, Maine, early in August, and destroyed some fields of grain and other crops. In Newport, Rhode Island, they overran several fields, eating all the grass and most of the cereals, including some cornfields. They were here fully as destructive as in 1861. They also appeared in Cambria and Chester, Pennsylvania; in Frederick, Maryland; in Craig, Grayson, and Augusta, Virginia; Tucker, Randolph, and Nicholas, West Virginia. Insects called Army Worms were destructive to oat crops in Ohio. In Fulton, where they had been previously comparatively unknown, they came by millions, cutting the stalks of oats and leaving the ground covered with the grain. Hancock lost 50 per cent. of the crop, which was also greatly injured in Henry, Van Wert, Fulton, Montgomery, Mercer, Auglaize, Crawford, Delaware, Lucas, Union, Warren, Morrow, and Adams. In Licking the general destruction of oats was supplemented by serious injury to the corn. They cut off the leaves and heads of the oats just ready to harvest. The insect is described as resembling the cut-worm, but a little lighter colored, being a light brown. In some cases they attacked every green thing. In Monroe and Branch, Michigan, they destroyed not only oats, but grass, corn, wheat, and rye. They are also reported in Franklin, La Porte, Whitely, and De Kalb, Indiana, and in Alexander and Ogle, Illinois.

From the regular entries of correspondents' reports we gather the following additional localities for this year: Montgomery County, Virginia; Knox, Greene, and Obion Counties, Tennessee; Logan County, Kentucky; Saint Genevieve (May 20), Boone, Perry, Howard, Gasconade, Montgomery, Madison, Cape Girardeau, and Bollinger, Missouri; in Pike, Perry, Jersey, Randolph, Madison, Sangamon, Monroe, and Clinton, Illinois; Logan and Medina, Ohio. From Clallam County, Washington Territory, came the following report:

Timothy attacked by Army Worms, which caused our farmers to commence haymaking sooner than they intended.

We supplement the above and conclude the record for 1875 by the following from our Eighth Missouri Entomological Report:

During the latter part of May, or just about the time that there was the greatest consternation regarding the locusts, our papers contained dispatches from various parts of Southern Illinois and Central Missouri to the effect that the Army Worm had

appeared in countless millions, and was destroying the grain crops at an alarming rate. During the last week of that month Mr. C. M. Samuels, of Clinton, Ky., brought specimens to my office with the statement that they were common and doing much damage all over the northwestern portion of Kentucky. It was also reported from various parts of Delaware and of Ohio about the same time. Somewhat later it appeared in Iowa, and I quote the following account of its advent at Fort Madison, from a letter from Dr. A. W. Hoffmeister:

"The Army Worm was very troublesome in some localities near Fort Madison. About the first of June immense numbers of caterpillars, one-half inch long, were observed in low grounds, subject to overflow or standing water. Their eating created a noise which could be heard at a distance as a dull grating or sawing sound. About the 21-24 they bored into the ground and pupated, and in about two weeks after appeared as moths. I had caught the *Leucania unipuncta* in the fall of 1875 and spring of 1876 in great numbers by the process of sugaring, looking at both seasons very fresh; and therefore it is a riddle to me whether there is another brood or whether some pupæ remain dormant till fall or next spring. All my pupæ hatched, but I did not see the moths cohabit, nor did I find young or new larvæ during the summer. This fall the moths are less numerous than last fall."

During the latter part of July and August it attracted attention in New York, and by the middle of the latter month was swarming on Long Island. In September and October it was extensively reported in New England, where it did much injury to Hungarian grass and to oats. Mr. B. P. Mann, of Cambridge, Mass., who took the moth at sugar as late as October 27, sends me the following extracts, which will show the time of year and the numbers in which they appeared in different parts of New England:

"Army Worms are very destructive to vegetation around Machias [Maine]. There has been nothing like them since 1861. * * * The Army Worms have appeared in large numbers at Colchester [Conn.], and are doing much damage to the crops."—[*Boston Daily Advertiser*, August 10 and 11, 1875.

"The Army Worm appeared in immense numbers on Sunday at Sussex, on the government railway line, east of St. John [N. B.], and since that time the ravages have created wide-spread alarm. Fields of grain have been destroyed. Horse rollers run over the road where they crossed did not perceptibly lessen their numbers. A dispatch from St. Andrews says, the Army Worm invaded that town yesterday, covering the streets, fields, and lanes in every direction, and devouring the grass and grain in spite of every opposition. They are still advancing."—[*Ibid.*, August 12, 1875.

"A worm has been discovered in Hollister [Mass.] in such large quantities as to lead to the supposition that it may be the Army Worm again. The army has invaded Delham. They have devastated an acre of Hungarian owned by Mr. Greenwood Fuller, a large field of grass for Mr. Luther Fisher; also for Mr. L. Baker."—[*Ibid.*, August 16, 1875.

"The south shore [of Mass.] in the vicinity of Black Rock has of late been visited with an innumerable host of moths, commonly called millers. They took possession of rooms, which were accessible by the windows being left open, in such numbers that it was the work of days to rid the rooms of their presence. Their origin is a mystery; but they entered rooms facing north in such flocks that it is a theory that they came in from the sea. In one small room 800 were killed."—[*Ibid.*, September 3, 1875.

The most noticeable feature connected with the appearance of the worm in our own State was its harmlessness, or non-appearance in the western or locust-stricken portion. Most of these counties are large stock-raising counties, and abound in rich prairie and good meadows. Under ordinary circumstances, the worms would have flourished there, but last spring, though I have records of their appearance, the locusts either destroyed them or caused them to starve before they acquired full growth. The following list

of counties in which no Army Worms were noticed or in which they were soon killed out, is made up from reports from my correspondents, and very forcibly illustrates the feature referred to: Andrew, Barton, Benton, Buchanan, Bates, Barry, Caldwell, Clay, Clinton, Cass, Cedar, Daviess, Dade, Dunklin, Grundy, Gentry, Henry, Harrison, Hickory, Holt, Jackson, Johnson, Jasper, Lafayette, Linn, Marion, McDonald, Macon, Newton, Oregon, Pulaski, Pettis, Putnam, Ray, Sullivan, Scotland, Saint Clair, Texas, Taney, and Vernon.

In nearly all of the counties not mentioned I have records of its appearance, and often in such numbers that whole fields and meadows were cut down.

1876.—The only reports for this year come from Saline and Chase Counties, Kansas, and the time of the reports (August) renders it probable that Laphygma not Leucania was the author of the damage.

In 1877 and 1878 we have no reports whatever of damage by the worms.

1879.—In the latter part of May the worms appeared in very injurious numbers in the grass fields of Norfolk, Princess Anne, Nansemond, and Isle of Wight Counties, Virginia, and a little later near Point Lookout, in Saint Mary's County, Maryland, in wheat. In July the worms were reported from Reno County, Kansas.

1880.—This year proved to be one of great damage to the Northwestern States. As early as February the worms were reported as being very injurious to winter wheat near Maryville, Blount County, Tennessee, and in Union County, South Carolina. About the 1st of June they were reported from Maryland, and soon after in Kent County, Delaware. Here, after destroying the wheat, they attacked the young corn, eating it to the ground.

Simultaneously with their appearance in Delaware, they were found on Long Island, New York, and in Monmouth County, New Jersey, creating great alarm, and doing much damage to the crops. The New York dailies contained column after column of information regarding the spread of the worms, and the injury done by them, much of it of course of a highly sensational character and totally unworthy of credence. In early June they appeared in the coast counties of Connecticut, and later in Massachusetts, appearing in Portsmouth, N. H., July 3. In various parts of Maine they were found during July, and August 12 appeared in destructive numbers in the vicinity of Halifax, Nova Scotia. Meantime, in June, they were found in the southern and eastern counties of New York, on Staten Island, all through New Jersey and Eastern Pennsylvania. Later there were isolated appearances of the second brood west. August 19, the worms did some damage in the vicinity of Indianapolis, Ind., and about the same time in Whiteside County, Illinois. In late July the second brood also injured the grass in Shenandoah County, Virginia.

Taken altogether, 1880 seems to have been equal to 1875 as an Army Worm year, and the two to have been second only to 1861.

1881.—This year the worms were reported from various parts of New York, Indiana, Illinois, Michigan, Wisconsin, and Iowa. In the first-named State, however, the injurious worms proved to be the Bronzy Cut-

worm (*Nephelodes violans* Guenée) and a smaller Pyralid larva (*Crambus vulgivagellus*) both of which are treated of in the Report of the Entomologist of the Department of Agriculture for 1881–'82. In Wisconsin all the reports investigated proved unauthentic and referred either to the White Grub (larva of *Lachnosterna fusca*) or to the Corn Worm (*Heliothis armigera*). Many of the newspaper reports from Michigan were also unreliable, though Prof. A. J. Cook assures us that the genuine Army Worm was destructive in several localities in that State. He says in a private letter:

The devastations were confined to the southwestern part of the State. The counties damaged were, in order of seriousness of the attack, Saint Joseph, Kalamazoo, Van Buren, Allegan, Berrien. The damage to the oat crop was very great in some sections, amounting to almost a total loss. Corn was also attacked, and considerable damage done to this crop. The most damage was done during the second and third weeks of July. The seasons were the reverse of the rule generally adopted by this insect; 1880 was a very wet year in Michigan. Last year was very dry. It was asserted that there was a second invasion in September. Though this was reported in several localities in the same region that was invaded in July, I have no positive knowledge that the insect noticed in September was the true Army Worm.

In Iowa one account at least plainly shows that the worm indicated by this name was the Tent Caterpillar of the forest (*Clisiocampa silvatica*). In Illinois and Indiana, however, there was no mistake, and the damage done in these two States, chiefly to oats, though partly to corn, grass, and flax, was very great. The contiguous border counties of the two States suffered most severely.

CHARACTERS; DESCRIPTIVE.

This division of the subject is intended to be purely descriptive, and to contain no material whatever upon habits. The necessity of including such descriptions in this chapter is clearly evident, for in 1881 other destructive worms, some of them allied to and others bearing not even family relation to the Army Worm, were mistaken for it.[31] The minutest details as to the characters of the worm in its earlier stages are in fact necessary to prevent such confusion, since without them it is almost impossible at such early age to distinguish between related species that may closely resemble each other and yet have very different habits. The portions here placed within quotation marks are taken from the Eighth Missouri Entomological Report, with a few verbal or typographical changes.

THE EGG. (Pl. I, Fig. 3, *g*, *h*.)

The egg of the Army Worm is spherical, smooth, white, and opaque when first laid, becoming faintly iridescent and more sordid before hatching. Its average diameter is 0.6^{mm} (.023 inch), and its perfect outline is sometimes altered by the gummy substance which is exuded by the moth at the time of ovipositing.

[31] See *American Naturalist*, July, 1881.

THE LARVA. (Pl, I, Fig. 5.)

First stages.—"When newly hatched, 1.7mm long, dull translucent white in color, with very minute piliferous points giving rise to pale hairs. Head large and uniformly brown-black. Two front pair of prolegs atrophied so as to necessitate looping in motion. Drops by means of a web. In the *second stage* it is quite active, still loops, and spins a web, and drops at least disturbance. Head copal yellow, with six black ocelli (the two inferior somewhat separated from the others), the brown jaws and brown marks on the legs conspicuous. Color of body yellowish-green, darker anteriorly, the venter being quite pale. The lines of mature larva barely indicated in faint rose-brown, the most conspicuous being the broad stigmatal, a narrower one above it, and two which are medio-dorsal. In the better marked specimens, the body above the pale substigmatal line consists of 8 dark and 7 pale lines, the middle pale line medio-dorsal, the second dark one from it most faint and most often obsolete, and the lower or stigmatal one broadest and most conspicuous. Black piliferous dots distinct and normally arranged, *i. e.:* on the middle joints 4 trapezoidally on dorsum; 2 in stigmatal dark line, one just above, the other just behind stigmata; one at lower edge of pale substigmatal line near the middle of the joint, and several that are ventral: the dorsal ones on joints 1 and 12 forming a reversed trapezoid to those on middle joints; on jt. 11 a square, and on jts. 2 and 3 a transverse line. In the *third stage* there is little change. The head has still a copal yellow aspect, being pale, with faint yellowish-brown mottlings; the ocelli still conspicuous. The body is more decidedly striped, the dark stigmatal and pale substigmatal lines more strongly relieved, and all the lines approach more to those of final stage. The pale hairs from piliferous dots are still quite noticeable, especially before and behind, and the dots themselves are generally relieved by a pale basal annulus. The looping habit is lost, but the front prolegs are still somewhat the smallest. It now curls round, and does not spin in dropping. In the *fourth stage* the aspect is quite changed, the general color being dull, dark green. The head has the mottlings of a deeper brown and the characteristic brown lines appear. The second pale line (from above) is obsolete, and the other five are narrowed, pure white, and sharply relieved by dark shades. The prolegs are of nearly equal size; the cervical shield better defined: in short, except in the lighter substigmatal stripe and more greenish color, the characters of the more normal, mature larva obtain. In the *fifth* and *sixth stages* the changes are mainly in the increasing prevalence of the brown and ferruginous colors, and the greater relief and intensity of the black, especially above the upper white lateral line. The front prolegs in the last stage are, if anything, longer than the hind ones. I reproduce herewith, with a few additions, my original description of the

Full-grown larva.—"General color dingy black, appearing finely mottled and speckled under a lens, with the piliferous spots placed in the normal position, but scarcely visible, though the soft hairs arising from them are easily seen with the lens. Four lateral light lines, of almost equal thickness, at about equal distance from each other, the uppermost two white, the lowermost two yellow; a much less distinct mediodorsal white line, frequently obsolete in middle of joints, and always most distinct at the divisions; a jet-black line immediately above the upper lateral white one, the dorsum near it thickly mottled with dull yellow, but becoming darker as it approaches the fine dorsal white line, along each side of which it is perfectly black. Space between lateral light lines 1 and 2, from above, dull yellow or reddish, the white lines being relieved by a darker edge; that between lines 2 and 3 almost black, being but slightly mottled along the middle; that between 3 and 4 yellow, mottled with pink brown, and appearing lighter than that between 1 and 2. Venter greenish-glaucous, mottled and speckled with neutral color, especially near the edge of the 4th lateral line. Legs glossy and of same color as venter; those on thoracic joints with black claws; those on abdomen with a large, shiny, black spot on the outside. Stigmata oval, black, and placed in the 3d lateral light line. Head highly polished, pale grayish-yellow, speckled

with confluent fuscous dots; marked longitudinally by two dark lines that commence at the corners of the mouth, approach each other towards the center, and again recede behind; on each side are four minute, polished, black eyelets, placed on a light, crescent-shaped ridge, and from each side of this light ridge a dark mark extends more or less among the confluent spots above. Cervical shield polished and mottled like the head, with the white medio-dorsal and upper lateral lines running conspicuously through it. Anal plate obsolete." Length, 1½ inches (38mm).

"These descriptions apply to the average specimens, but there is considerable variation in all stages."

THE PUPA. (Pl. I, Fig. 4.)

The pupa is of a shiny mahogany-brown color, with two stiff, converging, black thorns at its anal end, and, each side of the thorns, two fine curled hooks. It is from 18mm to 20 mm (¾ of an inch) in length, and is rather stout; in other respects not differing decidedly from allied species.

THE MOTH. (Pl. I, Fig. 1, *a*.)

The parent moth is variable in size, the average individual measuring about 40mm (an inch and a half) in wing expanse. The front wings are pointed at the tips, and are of a reddish gray or fawn color, much specked with black atoms. Anterior of the center of each wing are two rather large, indistinct spots, distinguished from the rest of the wing by an absence of black specks, and by a clearer reddish coloring. Immediately posterior to the outermost of these spots is a white point indistictly surrounded by blackish. A series of black points parallel with the outer margin; one on each vein is usually perceptible. An oblique black streak starts from this line of dots, and ascends to the apex of the wing, and, with the form of the wings, principally characterizes the species. Just inside the fringe is a serious of black dots, one between each two veins. The hind wings are translucent, gray, with the terminal border and the nervures blackish (in the front wings the nervures are whitish). The sexes differ from each other but little.

The under side of the wings is of an opalescent yellowish white. Along the outer margin, particularly of the hind wings, are many black specks, so nearly confluent as to form a definitely limited dusky terminal band. On the costal margin of each fore-wing, near the tip, is a small, distinct, black dot, and at the center of each hind-wing is a similar dot. The body is concolorous with the wings, and the legs are light gray, slightly tinged with reddish, and speckled with black dots.

SEXUAL DIFFERENCES.

"As throwing light on the mode of oviposition the sexual characteristics interest us. The sexes at first glance are not easily distinguished. There are no colorational differences, nor does the abdomen of the one sex differ materially in size or form from that of the other. Yet a careful examination with an ordinary lens will enable one to separate them with sufficient certainty by the smoother antennæ (Plate 1, Fig. 1, *e*) and more pointed abdomen (Fig. 1, *b*) of the female, compared to the more hairy or ciliate antennæ (Fig. 1, *d*) and blunter abdomen of the male (Fig. 1, *a*). The antennæ of the female will generally be found quite naked toward the base, while those of the male show two rows of stiff hairs, about half as long as the antennal width. In both sexes the tip of the abdomen is covered with a brush of long, pale hairs, and the moment these are brushed away the sex is at once easily ascertained. Suppose now we pick out a male for examination! A little friction

with a stiff camel's-hair brush will soon denude the tip of the abdomen without injuring the horny parts, when we shall notice two rounded, brown, horny lobes or clasps extending somewhat beyond the ultimate joint (Plate 1, Fig. 2, *A*), the lobes some distance apart below, but converging until they touch above. A careful removal of the chitinous exterior of the two terminal joints will further reveal to us that these lobes are but parts of a somewhat complicated arrangement, admirably adapted for seizing the female, and consisting chiefly of the two lobes referred to, of two smaller, inferior lobes, and of two intermediate organs starting from a knotty base, the upper one curved and ending in a sort of beak, the lower one more straight and ending in a small cushion of contracted membrane above.

"A still more careful examination will show that the upper valves (Fig. 2, *c*) have a rather long and gradually narrowing stem, and that they broaden irregularly, the hind border obliquing beneath and the lower border more strongly curved than the upper; all the borders are thickened, the outer surface is polished and dark brown, and the inner surface is clothed with stiff, pale, decumbent hairs, replaced toward the posterior portion with brown, retrorse spines (Fig. 2, *h*). The lower valves (Fig. 2, *d*) have a shorter stem and are more regularly rounded: each is composed of two corneous layers, soldered and somewhat thickened at the borders; the outer piece easily fractured and detached, pale, and covered sparsely with very minute spines; the inner one more solid, darker, and covered with a dense brush of long, pale hairs. The upper intermediate curved organ reminds one, from the side, of a swan's neck and head (Fig. 2, *e*); it is yellowish and cylindrical, dilated and enlarged toward the end, and terminates in a narrower, darker beak; the sides of the dilatation behind are curled up (Fig. 2, *g*) and furnished with long, yellowish hairs behind, and the beak with a brush of shorter hairs. The lower organ, or penis (Fig. 2, *f*), is broader, composed of membrane supported by two principal ribs—the upper one curved, the lower nearly straight—and ends in a sponge-like, superior swelling, which in life may be considerably extended in the form of a tube. Both these intermediate organs play on a strong horny arch, which is generally retracted, but which can be raised and exserted and considerably dilated as in Fig. 2, *B*.[32]

"If we now take a female, and denude the tip of her abdomen in the same way, we shall immediately find a quite different and far more simple structure, namely, a thin, vertical, blade-like valve, more or less produced or elongated on the upper portion, of a brown color, but with a broad, slightly thickened, paler border. This valve plays into two retractile subjoints of the body, and may be hidden within the terminal joint proper, so as to show only the upper tip, or extended as in the

[32] A careful examination of the genital organs of thirteen ♂s of this species shows very considerable variation in the contour and relative size of all these different parts—so much so as to convince me, when added to my limited examinations of the same parts in other species, that nice differences in these parts alone are of no specific value.

figure (Plate 1, Fig. 3, *a*). It is in reality composed of two thin layers, closely appressed except at the upper or dorsal portion near the base, where it swells into a somewhat angular ridge outside and is hollow within. A more careful examination will show that the upper portion is irregularly and obliquely striate (Fig. 3, *d*), the striations representing folds of the membrane, to facilitate expansion; and that the hind border is garnished with fine hairs, which easily rub off and leave the edge quite sharp, so that the two layers form a blade which is admirably adapted to pressing in between narrow passages, or even to splitting frail and hollow stalks. In life this ovipositor plays on the two subjoints, which may be greatly extended, and when so extended forms a somewhat cylindrical and telescopic tube, which is rendered very firm by a series of stout muscles within (Fig. 3, *b*). The valve opens from top to bottom, and may be very considerably distended, so as to make way for the oviduct, which is a quite complicated structure."

HABITS AND NATURAL HISTORY.

It was not until 1855 that the first step towards ascertaining definitely the life-history of the Army Worm was made, although, as we have already shown, it had been destructive at intervals for more than a hundred years before. In this year John Kirkpatrick reared the perfect moth from the destructive worm, and described both pupa and adult in the Ohio Agricultural Report for the same year. Our more extended knowledge of the subject dates, however, from the great Army Worm year of 1861. In this year Walsh, Kirkpatrick, Thomas, and Klippart at the West, and Fitch and Packard at the East, all improved their opportunities for studying the worm. To Walsh we are particularly indebted for a study of its parasites, though his views of its natural history have proved singularly unfortunate. To Fitch is due the credit of the correct scientific naming and the discovery of the synonymy. Kirkpatrick first described the most important of all the parasites—*Nemoræa leucaniæ*—and, in the light of later developments, he was remarkably correct in his ideas as to the number of broods and method of hibernation.

Yet up to 1876 no definite knowledge, based on observation and experiment, existed on some of the most important points in the natural history of the species. The eggs and the mode and place of oviposition were unknown; the question of hibernation and of the number of annual generations was still as open to discussion as when so warmly debated by Walsh and others, and many minor matters remained unsettled. Since 1876 we have been able to replace our uncertainty in these directions by positive knowledge, so that there are no questions having any important practical bearing that are now mooted in respect of this insect.

Concerning the Egg.

WHEN AND WHERE THE EGGS ARE LAID.—The favorite place to which the Army Worm moth consigns her eggs, in wild or cultivated

grass or in grain, is along the inner base of the terminal blades where they are yet doubled, or between the stalk and its surrounding sheath. They are by no means strictly confined to these situations, as is shown by the fact that we have known the moths in breeding cages to oviposit in crevices on the side of sward which had been cut with a knife, or even between the roots. In our first observations, which were made on low Blue Grass, the eggs were almost invariably found in the fold at the base and junction of the terminal leaf with the stalk; but later they were found thrust down between the sheath and the stalk, and occasionally in the natural curl of a green leaf or the unnatural curl at the sides of a withered leaf. The rankest tufts of grass, caused in pastures by the droppings of cattle and sheep, are preferred by the moth for oviposition, and, in these tufts, the oldest and toughest stalks; and in grain-fields also the ranker growth, caused by an accumulation of manure at some one spot or the previous existence of some fodder-heap or the like, is preferably chosen.

The observations of the present spring have satisfactorily proven that early in the season the moths oviposit by preference in the cut straw of old stacks, in hayricks, and even in old fodder-stacks of corn stalks. Old bits of corn stalk upon the surface of the ground in pastures have been repeatedly found, both in the vicinity of Washington and in Northern Alabama, with hundreds of eggs thrust under the outer sheath or epidermis, while the last year's stalks of grass in the fields around Washington have been found to contain these eggs in similar positions. The evidence collected in 1875, and published in our Eighth Missouri Report, seemed to show that where fodder stacks existed in grain fields the worms originated from them or from their near vicinity, and the observations just mentioned prove the correctness of the inference then made.

It has, however, been proven by this spring's observations that, lacking both stubble and fodder-stacks, the moth can and does oviposit in the spring in young winter grain. Mr. A. Koebele found in March, in the vicinity of Savannah, Ga., newly-hatched larvæ in the center of an oat field, the grain being one foot or more in height, and no straw stack in the vicinity.

As stated in the American Entomologist (III, p. 214), the moth will also, when exceptionally numerous, lay her eggs without concealment, and upon plants, such as clover, which the larva does not relish. As an instance of this, we stated in a foot-note that we had recently received from Professor Lintner, State Entomologist of New York, what were apparently the pressed eggs and egg shells of this moth, thickly covering clover leaves and mixed with an abundance of white gummy matter, with which the moth usually secretes them, all indicating that the moths had in this instance (doubtless from excessive numbers) oviposited abnormally.

Remaining concealed during the day, unless disturbed, or except in cloudy weather, the moth begins to fly at the approach of night, and, so far as observations have indicated, is engaged in ovipositing most actively during the earlier part of the night. It was at five or six in the afternoon when the first moth in 1876 was discovered in the act of egg-laying, but they have since been found at work most often in the early night-hours. The time of year when the eggs are laid will be discussed under the head of "Number of Annual Generations."

MODE OF OVIPOSITION.—We have already described the compressed, horny ovipositor of the female, which plays with great ease upon the two telescopic sub-joints of the abdomen. This organ, in the act of oviposition, is thrust in between the folded sides of the grass blade, and the eggs are glued along the blade in rows of from fifteen to twenty, and covered with a white, glistening, adhesive fluid, which not only fastens them together, but draws the sides of the grass blade close around them, so that nothing but a narrow, glistening streak is visible. This attempt at concealment is always made where the eggs are deposited in the leaf; but where they are thrust down between the sheath and the stalk, or otherwise naturally concealed, the gummy fluid is often very sparsely used, and sometimes not at all.

We have stated the number of eggs in a string at from fifteen to twenty, and this we believe to be about the normal number; but we have known as few as two or three to be deposited in confinement, and large batches of nearly a hundred eggs, in from three to eight rows, have been found in bits of corn stalk.

We have elsewhere expressed the opinion that the grass blades may possibly be clasped by the opening hind border of the ovipositor, so as to give the insect a firmer hold and close the leaf more firmly on the eggs, but more recent actual observation, in the field, of the movements of the moth during oviposition would indicate that this opinion is not well founded. She walks or flies around in the grass, alighting every few moments, until she finds a place that satisfies her. She then clasps the blade, her head almost invariably upward, or in the same direction with the blade. The front pair of legs clasp the blade, forward, the middle pair about the middle of the abdomen, and the hind pair about the tip of the abdomen, the wings being partly open meanwhile. The leaf is thus folded by the middle and hind legs, while the abdomen bends, and the ovipositor is thrust in as already described. She is thus engaged from one to three or four minutes at a given spot, according to the number of eggs laid, and then flies a short distance, and in a few minutes lays another batch. As we have known 30 eggs to be laid in two minutes, it would not require many hours to empty the ovaries, and a given female probably lays all her stock of eggs in one or two nights, though the time will vary with temperature and other conditions. We have known the moth to be so fixedly engaged in supplying a piece of old stubble with her eggs that she was unable to disengage herself when

first disturbed, and she was always so intent upon the operation as to render observation with a "bull's eye" sufficiently easy.

PROLIFICACY.—It is evident, when we consider the immense numbers in which the Army Worm often occurs, and when we also consider the number and importance of its natural enemies, that the moth must be quite prolific. The only recorded statement, however, is that in the Eighth Missouri Report, page 34, where the number of eggs indicated by a single dissection is stated to be upwards of 200. That this dissection, however, must have been made too early or too late is shown by the fact that two dissections, made the present spring, showed 737 eggs in the ovaries of one female, and 562 in those of another.

DURATION OF THE EGG STATE.—Observations made in Missouri, in 1876, indicate that the worms hatch from the eighth to the tenth day after the eggs are deposited; while others, more recently made in Washington, make the average duration of the egg in the month of May just one week.

Habits and Peculiarities of the Worm.[33]

HABITS WHEN YOUNG.—When the eggs have been laid in a green grass blade, the larvae, on hatching, feed for a time in the fold of the leaf. Where they hatch in stubble or old stalks, they remain sheltered therein for three or four days, issuing at night to feed, but going back for shelter. The newly hatched worms were also found by Mr. Howard under the frayed bark of the cedar posts around a wheat field at Huntsville, Ala., in such numbers and at such an early age as to indicate that they had hatched there. At this stage they are whitish in color, walk like loopers, in consequence of the atrophied, or rather non-developed first and second pairs of prolegs, and drop suspended by silken threads, or curl up, when disturbed. As has been so often said, during the early

[33] It will be interesting and important in this connection to translate Guenée's generalizations on the larvæ of this genus, as they may serve to help us to a more accurate judgment concerning one or two points in the life history of *unipuncta:*

"The larvæ of Leucania are all closely related in appearance, and even the most expert entomologist is often deceived by them. No European species, to my knowledge, is of a green color; all have a white dorsal stripe, and are of a carneous or brownish gray, with the ordinary lines well continued, and well marked, and between the lines a number of other lines or supernumerary bands, often resulting from a massing together of brown or reddish atoms. These usually constitute all the markings, but often the sub-dorsum is filled with black marks, which are not continued upon the rest of the segment. The stigmata are often wholly black or brown. These larvæ live exclusively upon the Gramineæ, and are to be found upon those which grow with their roots almost in the water, as well as upon those growing only upon the driest hillocks. Those which form thick tufts afford a natural shade, in the midst of which the caterpillars pass their lives, climbing to the extremity of the leaves only in the evening or even at night. Those which live on grasses with sparse leaves, by which they are not sufficiently shaded, hide themselves under brush or dry leaves a little distance away. Finally, some of them, which eat the leaves of aquatic grasses, hide themselves within the stalks the tops of which have been cut off by the hand of man or broken off accidentally. They bury themselves until stopped by a node, and their excrement, which partly fills these tubes, bears witness to the fact that they only leave their dwelling to take their food. This retreat, if it is not guarded from the punctures of Ichneumons, at least completely shelters them from the attacks of birds; but this is not its only use, for they utilize it still more when they reach the time for metamorphosis. They do not bury themselves in the earth, like their congeners, but content themselves with spinning, below and above them, two little partitions mixed with frass. The Leucanias which are ready for pupation in the latter part of the season pass through the winter in the larva state, and only undergo the metamorphosis in the spring."

part of their lives the larvæ are very similar in their habits to the many species of cut-worms, working upon the leaves of grass or grain during the night or in cloudy weather, and hiding during the bright sunshine. The fact cannot be too strongly insisted upon that the traveling of the worms in large armies is abnormal. During nearly the whole year, in regions subject to their incursions, the worms may be found in grass-fields, high or low (perhaps more often in the low lands bordering marshes, as they are here less liable to disturbance), feeding in the normal cut-worm manner. If their numbers be small, they may pass their entire lives in this manner, for it is only when so very abundant that the food of the vicinity is destroyed that the worms march in search of further supplies. Ordinarily one may pass daily through a grass plot where they abound, and never suspect their presence until the plot begins suddenly to look bare in patches. Thomas, in his First Illinois Report, states that, although he was particularly looking for the worms during June, 1875, he never suspected their presence in a constantly frequented grass plot behind his house until it was made manifest in this way, by which time the worms had disappeared, the abundance of their excrement, however, showing well enough that they had been there.

From the fact that the marching is abnormal, it always happens that in marching years many farmers insist that the sedentary worms ravaging their fields are not the true Army Worms, but simply the "ordinary cut-worms" which they have with them every year.

When young the worms mimic quite closely the plants upon which they feed, and this, with the habit of hiding as they do, by day, and dropping when disturbed, renders them very difficult of detection. The lighter color of the younger worms found thus concealed has given rise to the theory, put forth by Thomas and others, that the marching worms belong to a distinct race of the species; but there is not a particle of reason in such a theory, for the worms of the marching bodies possessed the same light color originally, and indeed the variation is such that the same color frequently persists with the full-grown worms, whether of the marching bodies or of the normal, hidden individuals. The deep color is largely the result of exposure, and whether the sedentary or marching habit predominates depends entirely upon circumstances.

Duration of worm life.—With so wide-spread an insect as the Army Worm it is impossible to make any general statement concerning the duration of any one stage which will hold good. In Saint Louis, in the vivarium, at an average temperature of 80° F., we found that certain of the worms passed through their five molts at intervals of three days, making the entire length of the larval life fifteen or sixteen days. The development, however, even of those hatching at the same time from the same brood of eggs, is quite irregular and may occupy several days longer. In northern Illinois Walsh gives the period at "from four to five weeks," while the shortest period of larval life that Thomas has observed is twenty-eight days. Individuals reared at the Department of

Agriculture indicate that in this latitude in late spring the period is from twenty to twenty-five days. Everything depends of course upon the temperature, the midsummer individuals passing through their changes much more rapidly than the spring and fall broods. As we shall show later, the Army Worm most often hibernates in the larval state, consequently the larval life of the last brood frequently extends over a space of four months or even more. In addition to the details published in our Eighth and Ninth Missouri Reports, the following observations recorded this spring will illustrate the great variation referred to:

Some eggs of the Army Worm moth which were deposited May 4, 1882, hatched May 11. The worms passed the first molt May 17, the second May 20, the third May 23, the fourth May 26, and the fifth May 29. On June 2 some of the larvae had entered the ground, and June 17 eight moths issued. May 28, some moths, collected during the evening of the 27th, were placed in the vivarium with grass. June 3 many young larvae had already hatched, and on June 20 some had entered the ground for pupation.

TRAVELING HABITS, ETC.—When the worms of a given locality are so numerous as to early exhaust their natural supply of food they begin to travel *en masse* to fresh fields. Their numbers at these times are often so enormous, and their voracity so great, that it is impossible for one who has not been an eye-witness of one of these invasions to appreciate it fully. To illustrate this point and also the habits of the worm, while on the march, we introduce the following quotations:

The Army-worm when traveling will scarcely turn aside for anything but water, and even shallow water-courses will not always check its progress; for the advance columns will often continue to rush head-long into the water until they have sufficiently choked it up with their dead and dying bodies, to enable the rear guard to cross safely over. I have noticed that after crossing a bare field or bare road where they were subjected to the sun's rays, they would congregate in immense numbers under the first shade they reached. In one instance I recollect their collecting and covering the ground five or six deep all along the shady side of a fence for about a mile, while scarcely one was seen to cross on the sunny side of the same fence. Though they will nibble at clover, they evidently do not relish it, and almost always pass it by untouched. They will eat any of the grasses, and are fond of oats, rye, sorghum, corn, and wheat, though they seldom devour any other part but the succulent leaves. They often cut off the ears of wheat and oats and allow them to fall to the ground, and they are perhaps led to perform this wanton trick by the succulency of the stem immediately below the ear. South of latitude 40° they generally appear before the wheat stalks get too hard, or early enough to materially injure it; but north of that line, wheat is generally too much ripened for their tastes, and is sometimes even harvested before the fullgrown worms make their advent.

I have heard of the Army-worm sometimes passing through a wheatfield when the wheat was nearly ripe, and doing good service by devouring all the chess and leaving untouched the wheat; but the following item from Collinsville, Ill., which appeared in the *Missouri Democrat*, contains still more startling facts, and would indicate that even a foe to the farmer as determined as this, may sometimes prove to be his friend.

"HARVEST AND CROPS.—Notwithstanding the unfavorable weather, many farmers have commenced the wheat harvest. The yield in this immediate vicinity will be superabundant. Some fields were struck with rust a few days since, but the Army

Worm making its appearance simultaneously, stripped the straw entirely bare of blades and saved the berry from injury. These disgusting pests have saved thousands of dollars to farmers in this neighborhood. A few fields of corn and grass have been partially destroyed, but, by ditching around fields, the worm's ravages have been confined within comparatively narrow limits." (Riley, 2d Mo. Ent. Report, pp. 54, 55.)

They avoid the rays of the sun; hence during the day they crawl under stones and sticks, as closely as they can crowd themselves together, and under swaths of grass or grain, or even into the ground, like the cut-worm. They rest in such places during the heat of the day, and come out towards sunset, to feed and continue forward in their mighty march. If they come to a field of grass or grain that is young and tender they devour the whole of it, down to the very roots; but if it is grown up to stalks, they eat the leaves only, and then usually crawl to the top of the stalk and cut off the head and drop it to the ground. In corn, too, they eat off all the leaves except the coarse keel or mid vein. One writer noticed a worm to eat a square inch of corn leaf in thirty minutes. It is leaves which are green and juicy that they eat; the dry leaves of ripened grain they do not feed upon. * * * They all keep together like an army of soldiers, and usually advance in a particular direction, in a straight line, not swerving from their course to avoid hills, hollows, buildings or any other obstacle. A stream of running water, even, does not cause them to deflect from their line of march. We learn from Solon Robinson that, on coming to a brook they crowd into it, although very few of them chance to be carried by its current to the opposite side. Millions of them are drowned, their dead bodies clogging and damming up the stream in places below, producing by their decay a stench in the atmosphere of the whole vicinity which is most noisome and intolerable. In their march they travel faster at some times than others, advancing at the rate of from two to six rods in an hour. Thus instances have occurred in which an army of these worms, two or three miles wide, have advanced six or seven miles, leaving the track behind them as desolate as though fire had swept over it. (Fitch, pp. VI, pp. 117, 118.)

They usually commence marching when about half or two-thirds grown; and so far as I have observed, those leaving one field all march in the same direction, but not always, as is supposed by some, with unfailing certainty, toward another field in which there is proper food, for in the case hereafter mentioned, where, in 1875, they left a meadow near our town, the movement was directly toward town—no field with any suitable food being nearer than a mile in that direction. Nor is it true that they always remain in one place so long as sufficient food is to be found there, for in more than one instance I have known them to leave a field abundantly supplied with suitable food and march into others. In one instance, where they attacked a field of oats and penetrated it a short distance, mowing it as they proceeded, they suddenly quit it. There does not appear to be any uniformity in the direction the different armies, or armies from different fields, take. In 1875, the army from one field was moving directly south, while that from another moved directly east. While marching, they move with rapid motions and apparently with an uneasy feeling, especially if the sun is shining. The following statement, from the *Prairie Farmer* of July 4, 1861, is probably not overdrawn:

"An army of them was observed to travel 60 yards in two hours, in an effort to get around a ditch. They began to travel from the infested districts between two and three o'clock, p. m.; toward sundown the tide of travel was retrograde. They did not travel at night; they feed chiefly by night and in the forenoon. As to their number, they have been seen moving from one field to another, *three tiers deep;* a ditch has been filled with them to the depth of *three inches in half an hour.*" (Thomas's Fifth Illinois Report, p. 16.)

The Army Worm is an epicure and therefore unlike the grasshopper and locust. When in moderate numbers they are more choice in the selection of their food than they can be where the fields are overrun by their hordes, then they select the tender-

est blades of some favorite grass or grain, leaving the midrib of the leaf untouched, but when, in the "struggle for life," each has to do the best it can for subsistence; nearly all grasses or grains come alike welcome, and all but the hard stems are devoured. In the oat field all the blades are eaten and the caterpillar ascends the stalk to the very top, and finishes by biting off nearly all the grains and letting them fall to the ground. As they do not eat the grain this may be looked upon as wanton destruction. We learn that in wheat or other grain fields, they often cut off the ears and let them fall to the ground. The only cause for this seems to be that they eat a portion of the finer parts of the peduncle or stalk. If the grain is cut previous to the worm leaving the field, and left out to dry, the insects will still continue feeding on the cut grain, and thousands may be found during the heat of the day, sheltered beneath the swath or bundles, so that it becomes necessary to remove the grain as soon as possible after cutting. The resting time of the Army Worm is during mid-day. Their feeding time, morning, evening and night, and at these times they also travel. When resting they are usually coiled up in circle or snake fashion. When traveling they move at a moderate pace, avoiding all steep places if possible, and preferring level land. They can climb well enough if the ground is firm or covered with herbage, but if loose and friable they lose their footing and fall back while endeavoring to climb any steep ridge. (Kirkpatrick, Ohio Agricultural Report, 1860, pp. 352,353.)

In regard to numbers, we may quote the following passage from the *New York Sun* of June 11, 1880, concerning the damage done in Monmouth County, New Jersey, in 1880:

A journey through a large part of Monmouth County revealed a singular state of affairs. Trenches were seen extending for miles along the roads close to the edges of the fields; but the crops, for the most part, were withered and lifeless, and it was evident that the precaution had been taken too late. Very often a long trench ran across a field of wheat, showing where a farmer had abandoned one portion of his crop and tried to save the remainder. Occasionally a field was seen intersected by numerous trenches, indicating that the proprietor had fought manfully against his persecutors, and disputed the ground with them foot by foot. * * * In many places the road was literally covered with the worms, all in motion, and all moving towards the fields on either side. Thousands and tens of thousands were crushed beneath the wagon wheels and under the horse's feet; but the rest pressed on. And at intervals spots were passed where an imaginary line seemed to be drawn across the road beyond which the army worm could not pass. For a certain space beyond, sometimes for as long a distance as two or three miles, not only the roads but the adjoining country was free from the pest. Not a worm was to be seen, until, the clear space passed, the wagon was again rolling over millions of them.

We have spoken in one of these quotations of the rate of travel, a writer in the *Prairie Farmer* stating that an army of the worms was observed to travel [illegible] yards in two hours. This would be at the rate of one foot and a half per minute. To show that this is not overdrawn, it may be well to state that individual worms have been timed when moving over a smooth surface under the impelling influence of a hot sun, and have been found to crawl at the rate of two feet and a half per minute.

TIME OF APPEARANCE.—A few years ago a paragraph could have been written under this head with the utmost ease. Within the past two years, however, facts have been gathered which complicate matters considerably. During the winter of 1879–'80, worms were received at the Department in March, February, and even January, from localities as far north as Tennessee and South Carolina, and noted as damaging

winter grain during these months. The winter was unusually mild and open and it was supposed that this fact accounted for the so-called unusual appearances. It has recently been proved, however, beyond all peradventure, that, over a large portion of the country, the species hibernates in the larva state, and that in favorable seasons the hibernating brood may be injurious to crops. It is, however, usually the immediate descendants of these hibernating worms which compose the injurious brood. During the past winter (1882) young hibernating worms were found in Washington in January. The same brood was injurious to winter wheat in February in Alabama, and, in early March, to wheat and oats near Savannah, Ga., and Columbia, S. C.

The injurious brood usually makes its appearance in Missouri and in Virginia in May; in Illinois, southern Ohio, Delaware, New Jersey, and Long Island, about the first of June. From the middle of June to the first of July it is found in Connecticut, Massachusetts, southern and central New York, Pennsylvania, northern Indiana, southern Wisconsin, and Michigan. From the latter part of July to the middle of August it appears in northern New York and New Hampshire, in Maine and southern Canada, New Brunswick and Nova Scotia.

Instances are not wanting also in which the immediate descendants of this second brood have also constituted the injurious brood, and thus occasioned very late reports of "first appearances," although such cases are rare. Kirkpatrick, in his 1861 article (Ohio Agricultural Report, 1860, p. 351), mentioned the fact that in Cuyahoga County (northern Ohio) the worms were that year not observed until the first of August, while less than eighty miles south, in Shelby County, the injurious brood pupated June 16. Another instance was recorded by L. O. Howard, in the New York *Semi-Weekly Tribune*, August 5, 1880, in which the worms appeared "for the first time" in Scott County, Virginia (one of the extreme southwest counties of the State), July 29, doing great damage to corn and German millet, while the previous year the injurious brood pupated in Norfolk County about May 30. There is much reason also for supposing that the brood just mentioned was the injurious brood in the Northeastern States in 1875; *vide* the following from our Eighth Missouri Report (1875):

> There may, therefore, be a difference of over two months between the appearance of the worms in southern Missouri or Kentucky and in Maine. Thus early in June of the present year, when I left home, they were mowing down the meadows and wheat fields in central Missouri and in southern Illinois, Ohio, Indiana, as well as in Kentucky; while upon arriving in New York two months later, they were marching through the oat fields of Long Island, and were reported very generally in the Eastern States. In Maine they appeared as late as September.

This would make the injurious brood on Long Island in early August, while in 1880, it will be remembered, they were causing great alarm in the same locality during the first week in June; a pretty plain case. The injurious brood of late July, 1881, in Illinois and Indiana, may also have been an example of the same fact.

SUDDEN APPEARANCE AND DISAPPEARANCE.—"Among the manifestations in lower animal life, few are more astonishing than the sudden occurrence of a species in vast numbers over large stretches of country, and its as sudden disappearance. In a few rare instances, as with the thirteen and seventeen year Cicadas, these manifestations are strictly periodical, and occur at regular intervals; but in the great majority of instances they have no such periodicity. The numerous natural checks which surround every animal, added to the meteorological conditions which affect it in its struggle for existence, sufficiently explain these phenomena to the intelligent naturalist, though it is not always easy to point out facts in specific cases. Under the head of 'Habits of the Worm', I have already given the reasons why it escapes attention in its earlier stages and in seasons when it is not excessively abundant." Hidden at the base of tufts of rank grass and feeding only at night, it may live for generation after generation, while the unsuspecting farmer little imagines that his dreaded enemy is so near. If there should come one or more seasons of drought, however,—weather extremely favorable to the increase of the worms,—they begin to multiply prodigiously, large numbers hibernate, and in the ensuing spring multitudes of moths fly out over the country, each filled with her seven or eight hundred eggs with which to stock the surrounding pastures and grain fields. The young worms hatching from these eggs and feeding in their normal cut-worm manner still escape the eyes of the farmer; "but when the bulk of them have passed through the last molt, or, in other words, are nearly full-grown, and have stripped the fields in which they were born, they are then obliged to migrate in bodies to new pastures. Thus assembled and exposed, they pass through grass and grain fields, devouring as they go; for they are now exceedingly voracious, and, like most Lepidopterous larvæ, consume more during the last few days of worm-life than during all the rest of their existence. The farmer who is unfamiliar with their life-habits wonders where they come from so suddenly, and presently, when they enter the earth to transform, he wonders again where they go to. In these exposed numbers, also, the numerous natural enemies of the worms congregate about them and do their murderous work far more effectively than when they have to seek individuals hidden here and there in rank grass; so that we cease to wonder at the almost total annihilation of the species the year following its advent in such numbers."

Dr. Fitch, in his sixth report, proposed a theory to account for these seemingly unaccountable appearances of the worms, which, first and last, has caused much discussion. In his own words it is stated as follows:

The spring and early summer of this year [1861] was exactly the reverse of last year—unusually wet, and the water high in all our streams. Hereby the swamps have all been overflowed, and this insect has been drowned out of them. The moths or millers on coming out of their chrysalides, found it was impossible for them to get to the roots of the grass there, to deposit their eggs. They were obliged to forsake their usual haunts and scatter themselves out over the country, the incessant rains making

it sufficiently wet everywhere to suit their semi-aquatic habits. Thus going forth in companies, they alighted in particular spots, and there dropped their eggs; and the result is sufficiently well known.

More briefly expressed my view is this—a dry season and dry swamps multiplies this insect. And when it is thus multiplied, a wet season and overflowed swamps drives it out from its lurking-place, in flocks, alighting here and there over the country. But on being thus rusticated, it finds our arable lands too dry for it; and immediately on maturing and getting its wings again, it flies back to the swamps, whereby it happens that we see no more of it.

Dr. Fitch starts, in the first place, with the supposition that the natural food of the Army Worm is the coarse, wild grass of the swamps and bogs, and that here, and here only, is it found in the interim between "worm years." It is only necessary, in order to disprove this, to search diligently in spring among the tufts of grass upon knolls and hill-sides as well as along marshes, around the borders of grain fields, and even in the grain fields themselves. Army Worms will almost certainly be found in all these localities. The species probably does flourish to a somewhat greater extent around swamps, but it is for the reason that the grass in such localities is not so apt to be grazed closely or cut. Moreover, the parent moth very probably gets more appropriate food in such places, either in saccharine exudations, the natural "sweat" of the plants, or in the moisture from the ground.

Moreover, an examination of the weather records shows us that while the years preceding Army Worm years have been universally characterized by drought, the years in which the worms have actually appeared have not necessarily been wet,—a fact which in itself is a death-blow to the theory. In support of this fact we made use of the following arguments in the *American Entomologist* for September, 1880:

That the Army Worm appears in destructive numbers after a period of dry seasons is a fact already recognized, and is in accordance with the experience of the present year. The portions of our country visited by the worm this year were afflicted with drought last summer, and the winter was remarkable for its mildness and the slight fall of snow. Fitch's theory of the appearance of the worm required that this spring should be a wet one in order to drive the moths from the swamps and cause them to lay their eggs on the upland. But the facts are just the reverse. Farmers from Virginia to Vermont have complained loudly of the excessive drought. Rivers in some of the Atlantic States have not been so low for a generation, and alluvial meadows which have been subject to a spring flooding, have this year remained dry. These facts clearly disprove Fitch's theory, and we must believe that the Army Worm is most likely to appear after dry seasons, *regardless* of the wetness or dryness of the season in which it occurs. A critical examination of Fitch's arguments in support of his theory shows that he not only had no personal acquaintance with the worm, but also made some false meteorological deductions, such as comparing the rainfall of India (?) with the appearance of the worm here! With equal reason might we argue that 1879 was wet in our Atlantic States because of the excessive precipitation in the British Islands during that year. It is evident that Fitch was hard pressed for arguments to support the theory. That the season of 1861 was remarkably wet in the Eastern States, Fitch gives no evidence, and while the mean rainfall, according to statistics was greater in 1861 than in 1860, it does not follow that the spring and early summer of 1861 were, on that account, unusually wet. From the well known connection of

the presence of plant lice with dry seasons, and from the memorable depredations of the grain aphis in that year throughout the Middle and New England States, it is very questionable whether the summer of 1861 was wet. It is far more probable that the season was a dry one like the present, in which also various plant lice have done great damage.

The sudden disappearance of the worms, which Fitch accounts for by the supposed fact that the insect "finds our arable lands too dry for it; and immediately on maturing and getting its wings again, it flies back to the swamps," is much more easily and naturally accounted for in view of known facts, as we have accounted for it above, by the increased effectiveness of its very numerous natural enemies, and by the enormous numbers destroyed by the hand of man.

FOOD-PLANTS.—The normal food-plants of the Army Worm are found among the grasses and grains, not a single species of either, so far as known, coming amiss. Wheat and oats seem to be their favorites among the small grains, though rye and barley are also taken with less relish. German millet, corn and sorghum are eaten by the worms, particularly when young and tender. They were found last year feeding to a greater or less extent on flax in Illinois, although this is mentioned by Fitch as one of the crops which the worms will not touch. They have also been known to eat onions, peas, beans, and other vegetables, though probably only when pressed with hunger. As stated in our Eighth Missouri Report, upon the reliable authority of Mr. B. F. Mills, of Makanda, Ill., they have also been known to eat the leaves of fruit trees. Ordinarily clover is disregarded by the worms, though they occasionally nibble at it. A timothy field is often eaten to the ground, leaving the clover scattered through it standing. In 1880, in Monmouth County, New Jersey, occurred remarkable exceptions. We quote from Rev. Samuel Lockwood:[34]

I had supposed the aliment of these insects to be restricted to the *Gramineæ*, that is, the grasses proper and the grains and Indian corn. Hence, surprised at the thoroughness with which they had eaten up that field of clover, on the spot I took it for an original observation of an exceptional habit; but, upon looking into the Riley reports, I found similar facts on record. I soon ceased to regard this habit as at all exceptional; for, so far as Monmouth was concerned in 1880, clover-eating by the Army Worm was the rule and not the exception. In fact, I could not learn of one instance of their presence in which the clover escaped. The following from a letter by a teacher is to the point:

"On the farm of Charles Allgor, at New Bedford, in passing from his wheat-field to his oat-field, the worms had to cross a strip of sward composed of timothy and red clover of three or four years' standing. They took every thing clean. They also ate the young clover in the bottom of the wheat-field, killing it entirely. In a mixed sward of Geo. Newman's, the teacher, they ate the clover as well as the grasses, leaving nothing but the stalks. They also ate the clover on the farm of Albert King, at Green Grove. They did not make a specialty of clover, but they ate it without being starved to it. They ate both the clover and timothy in a mixed sward of James Allgor's. They ate Mr. Allen's oat-field, then went over to his sward of grass and clover, and finished that off, too."

[34] See Mr. Lockwood's Report, further on.

In this connection it may be well to state that on the Department grounds at Washington the newly-hatched worms have been found in a folded clover leaf, feeding thus protected, and under such circumstances as rendered it probable that they had hatched there. We have already given instances of egg-laying on clover.

Mr. Lockwood also states in his report, that even the common ragweed (*Ambrosia artemisiæfolia*) was eaten clean by the worms, and also, that the worms in passing through a strawberry patch devoured both the leaves of the plant and the unripe fruit.

In June, 1882, specimens of the worms were received from Mr. Chas. G. Rockwood, Hammonton, Atlantic Co., N. J., with the statement that they had done great damage to his cranberry crop.

Experiments made at the Department during June, 1882, showed that the worms in confinement will live, thrive, and undergo their metamorphoses when fed exclusively upon any of the following plants: garden poppy, beet, lettuce, cabbage, raspberry, onion, parsnip, radish, carrot, and pea. They refused to feed, however, on bean, cotton, grape and hemlock, while on strawberry they fed slightly, but all died. It will be noticed that eight botanical families are represented among the plants on which they thrived, viz.: *Papaveraceæ*, *Chenopodiaceæ*, *Compositæ*, *Cruciferæ*, *Rosaceæ*, *Liliaceæ*, *Umbelliferæ*, and *Leguminosæ*.

It may also be well to state, finally, that, like its southern prototype, the Grass Worm (*Laphygma frugiperda*), the Army Worm when on the march does not hesitate at cannibalism to satisfy its hunger, and many individuals are killed and devoured by their stronger fellows.

Duration of the Pupa State.

Upon reaching its full growth the Army Worm ordinarily burrows for an inch or more below the surface of the ground, and there transforms to the pupa which has been previously described. Often, however, when occurring in great numbers, this precaution is not taken, and the worms pupate under stones, boards, logs, or other rubbish, without entering the ground. More or less silk is spun around the body at such times and particles of dirt attached to it. The duration of the pupa state varies of course with the climate and season. Ordinarily northern writers place it at from two to three weeks. Mr. D. W. Coquillett, in raising the worms in northern Illinois, found the length in July to vary from nine to sixteen days through the intervening times of ten, eleven, thirteen, and fourteen days. The moths issued most abundantly after thirteen and fourteen days. In our breeding cages both at St. Louis and Washington the average period in midsummer has been about thirteen days.

Habits of the Moth.

FOOD.—Few actual observations have been made upon the food of the moths. They undoubtedly feed upon the nectar of various flowers. Mr. D. W. Coquillett has taken them in the evening upon the blossoms

of clover, and also upon the common soap-wort (*Saponaria officinalis*). Our assistant, Mr. Koebele, has also taken the moths feeding on blossoms of apple, honeysuckle and yucca. It is moreover probable that one of the reasons for the more frequent appearance of the worms on lowlands is that the parent moth gets more appropriate food at such places, either in saccharine exudations—the natural "sweat" of the plants ("*Honigausschwitzung*" of the Germans)—or in the moisture from the ground. The microscopic examination of the tongue shows it to be strongly armed, like those of so many allied genera, and it is highly probable that, like the Cotton Worm moth, Leucania not only feeds upon cracked or decayed fruit, but that it will also upon occasion pierce sound fruit and suck its juice. Of this, however, we have only presumptive evidence.

The eggs develop rather slowly in the ovaries of the moth, and even with the midsummer brood at the South a week or more elapses between the issuance from the pupa and the commencement of oviposition. Dissections made at Saint Louis in 1875 showed that the moth lives without doubt for several weeks in autumn ; hence the necessity for considerable food.

FLIGHT.—The flight of the Army Worm moth begins toward the latter part of the afternoon. It is low and is characterized by a quick, darting motion, accompanied by a slight humming noise, similar to but less intense than that made by hawk moths. Professor Thomas says:

> They began to leave the ground of an evening about sunset, but appeared in greatest abundance about the time it became fully dark. Their flight is strong, irregular and plunging; darting from side to side for a short distance, they dive suddenly into the grass with a force which would seem to be sufficient to tear their wings to pieces. They fly low, seldom rising more than a few feet from the ground; at least none entered the window of my bed-chamber, which is on the second floor, and opens directly opposite and almost over the spot from which the greatest number came. But they do not appear to be as readily attracted by light as many other moths.

Exceptionally, however, the moths fly higher. One of the Department agents, last summer, at Savannah, Ga., captured several which had been attracted by the light in his room in the second story of the Marshall House, and we have repeatedly taken them in the third story of our own dwelling.

POSITION WHEN AT REST.—During the day the moth remains, ordinarily, hidden in grass, weeds, or other rubbish. When at rest its wings are either held flat upon its back, opening slightly and showing the edge of the hind wings, or more sloping (see positions, Pl. II, Rep. Ent. Dept. Agr., 1881–2). Upon first alighting the wings are kept in motion with a rapid quivering, but this movement soon ceases and they sink into the position described, with the tips resting often upon the supporting object or surface.

NUMBER OF ANNUAL GENERATIONS.

"From the time Fitch wrote so fully on the species in 1861, until the record of our observations in 1875 and 1876, it was the prevailing belief

among entomologists that there was but one annual brood of the species, especially in the Northern States, no absolute evidence of a second brood having been obtained."

It is true that Professor Thomas, in the *Prairie Farmer* of June 20, 1861, expressed his belief in two broods, and in the same periodical, August 22, 1861, made the following statement:

A few years back when the Army Worm appeared in this county, after disappearing, they were again seen on some farms, late in the fall, in considerable numbers. In one place they were in such numbers that they cut all the grass in a corn-field and even attacked the hard leaves of the ripening corn.

This is evidently from hearsay, and cannot be considered a well-authenticated instance, because such accounts in the fall generally refer to *Laphygma frugiperda;* yet in 1880 Thomas says (10th Ill. Ent. Rep., p. 27):

In fact I brought forward *absolute evidence* of the correctness of this opinion by showing at least one *well-attested* case of both the spring and fall broods of the worms appearing in this county the same year in large and injurious numbers.

Kirkpatrick had also expressed his belief that there were two broods, but with these exceptions entomologists considered the insect one-brooded; indeed, Thomas, later, gave up his belief, as he says, and sided on this point with Walsh (*Prairie Farmer*, October 31, 1861, p. 293). In 1880 we wrote:

Our experiments in 1876 proved conclusively that there were always two and sometimes three generations in the latitude of Saint Louis. The facts that we also recorded as to the remarkably rapid development of the worm, *i. e.* that it can reach full growth within a fortnight after hatching, lent favor to the idea, in our mind, that there might be even more generations. Subsequent experience, and especially that of the present year, has convinced us that there is usually one other generation there, and it is but natural to suppose that there are still more in more southern latitudes. The moths are to be found laying their eggs as soon as vegetation starts in the spring, and there is a succession of broods from that time till winter sets in; the number differing according to latitude and the length of the growing season. Thus, Professor Comstock reports it as having been received at the Department of Agriculture, in the larva state, during every month of the winter of 1879–'80 from the Southern States, where, during the mild weather, it was active and injurious to oats and other grain. (American Entomologist, v. 3, pp. 184, 185.)

The winter of 1880–'81 was so severe all over the country that the worms were not noticed; but in the winter of 1881–'82 they again made their appearance.

Sod was taken from the Department grounds at Washington and placed in breeding cages as food for other larvæ shortly before Christmas. January 3 a number of young Army Worms, which had evidently been hibernating at the roots, were found feeding upon the grass leaves. January 12 an active larva one-third grown was taken, out of doors. January 15 another larva which had passed through its second molt was found under similar circumstances. The first moth from these larvæ made its appearance March 3. January 23 the worms were received from Ashland, Clay County, Alabama, with the report that they were

destroying the wheat crop and causing a great deal of excitement in the county.

In March, again, they were working injury to winter grains in Georgia and South Carolina, and Mr. Koebele, as already stated, found worms of all sizes at work at Savannah and Columbia. Again, in the first week in May, they appeared in enormous numbers in northern Alabama and southern Tennessee, and there is presumptive evidence that, counting the hiberating worms as the first brood, these worms represented the third brood for these localities.

There is no doubt that the prevailing theory of its single-broodedness was a result merely of the fact that it is observed in excessive numbers only once during the year, and usually when wheat is just about ripening. But, as we showed in our Missouri Reports (Eighth and Ninth), the worm is always to be found both earlier and later in the season, but attracts no attention because living in its normal cut-worm condition.

In his report for 1880, Professor Thomas has a lengthy discussion as to the number of broods—the most extended discussion, in fact, yet published. Although he has drawn his data industriously from all published sources, they are still very insufficient, and he has committed the great mistake of massing together statements in regard to the length of life of the insect in its different states, from Missouri and southern Illinois to Massachusetts, taking as the *minimum* length for each state the life of the insect in that state when reared in the breeding cage. His conclusions seem to be, although it is difficult to get at them, that, while in the South there may be more than two broods, in Illinois and the Eastern States, as far north as central New York, there are two, and two only. One of his concluding statements is: "From these facts, we believe we are justified in concluding that it is impossible for a third brood of worms to be produced, which shall pass the winter, in this State [Illinois], as Prof. Riley assumes, in his articles of 1880."

The matter of hibernation we shall consider farther on; but the error in his conclusion as to the impossibility of a third brood in Illinois is easily shown by actual observation.

In 1881 the injurious brood in Illinois, according to the observations of Mr. Howard, pupated in Iroquois County from July 18 to 30, the first moths appearing August 1. Taking into consideration the fact that in former years the injurious brood has pupated during the first or second week in June, and calling the hibernating brood the first, this injurious brood would already represent the third. But this is not necessary to our purpose. Mr. Coquillett, working for the Entomological Commission, began his observations July 14, in McHenry County, northern Illinois. He found an injurious brood which pupated July 19, and gave forth the first moth August 1. August 3 a number of moths were captured, and from this time on for several nights several were captured each night, after which no more were seen. August 18 a young Army Worm was found; August 22 another, and August 26 still another. The first week in Sep-

tember two worms were found. September 23 a nearly full-grown worm was found feeding upon a head of timothy, and the same day three more were found hiding beneath a board, one of them tachinized. Of the worms found early in September, one pupated September 22, and issued as a moth some time before the 15th of October; the exact date of issue is not known. Of the worms found September 23, one pupated a week later and issued as a moth October 22; the rest died. October 29 a worm measuring one-half inch in length, or less than half grown, was found. November 1 four more were found, one seven-eighths of an inch in length, and the rest three-fourths of an inch long. November 4 another was found three-eighths of an inch long, and on the 5th one more measuring one-half inch. These last worms were all found, according to Mr. Coquillett, under or in shocks of corn, and we think would evidently have hibernated in these localities.

Thus, even admitting the injurious brood of July to have been only the second (hibernating worms constituting the first), we have *three* broods in northern Illinois plainly demonstrated, the worms of August and September constituting the third brood and the offspring of the October moths the hibernating brood or the first of the present season. The case is made all the stronger when we consider that a half-grown worm was found August 23, which, had it been reared to the perfect state, would probably have given forth the moth before the first of October.

We have already shown that the injurious brood is usually the second, but have also given instances which indicate that it is occasionally the third. We have every reason to suppose that Thomas's estimated average length of life of the individual—seventy-seven days—is too long, even for the more northern portions of the country. The experience of every entomologist will show that in summer an insect will occupy a longer time in undergoing its transformations within the breeding cage than in the field under natural conditions, and yet Thomas has taken the vivarium life as the *minimum*.[35] We have shown by experiment that indoors

[35] Mr. Lintner's paper on a somewhat similar subject, viz., the life duration in Heterocera, gave a long series of careful notes of collectings, from which he concluded that the average duration of moths is from two to three weeks in summer. The paper gave rise to some extended remarks from Messrs. Thomas, Mann, Riley, and others. Mr. Thomas thought that the knowledge of the term of life in the imago was of less value, from an economic standpoint, than that of the individual in all its states. In endeavoring to ascertain this duration in *Leucania unipuncta*, he had come to the conclusion that it was about seventy-seven days. This conclusion, based on calculations from recorded appearances of the insect, was in opposition to the only actual experiments which are on record, viz., those by Mr. Riley in the Eighth and Ninth Reports on the Insects of Missouri, which show that the term of life in summer barely extends over half as many days. In fact, all our experience as to the summer duration of life in this species shows that the states of egg, larva, chrysalis, and imago average forty days. Mr. Thomas argued that insects in confinement develop more rapidly than in freedom. Mr. Riley gave his experience as opposed to the statement: insects reared in confinement during the summer are likely to develop more slowly than in freedom, for the obvious reason that those in freedom get more sunlight and constantly have a supply of fresh food at hand, and this will hold equally true with the changes that take place underground, for the mean temperature of the soil, during summer, is evidently greater outdoors than indoors. Experience shows, moreover, that in this question everything depends on the time of year, the character of the weather and other surrounding conditions, there being a wide range in the duration of life in the same species.—(Adapted from *Amer. Naturalist*, Nov., 1881, p. 912).

the round of the insect's life may be completed, under favorable circumstances, in less than forty days. It would be difficult to give any exact number of broods for the southern parts of the country, for, as we have already shown, with mild winters a succession of generations is maintained during the whole year without any so-called dormant or hibernating period. In other years the hibernating period varies with the length of the severe winter weather, and of course the number of generations is influenced thereby. Moreover the confusion of generations is so great that it will always be difficult to ascertain positively the number of broods in a given year.

At the North the same facts hold, though in a lesser degree, and we believe that the same number of broods which we have proven for northern Illinois will hold for all points between the Ohio River and the Great Lakes and north to central New York, namely, normally three and possibly or exceptionally four.[36]

HIBERNATION.

In the course of the discussion of the habits and natural history of the Army Worm, extending over the last twenty years, hibernation in each one of the four stages has had its strong advocates. Walsh, in his many articles, upheld most emphatically the probability of hibernation in the egg state, bringing what seemed to be strong arguments to its support. Thomas, French, Kirkpatrick, Klippart, and others have as strongly supported pupal hibernation, while in the Missouri Reports we have given reasons for supposing that the species may hibernate both as larvæ and as adults. Comstock, in his 1879 report, upheld the hibernation of the moth as the only proved method. The discussion of this point from our Eighth Missouri Report (1875) will bear repetition:

Accepting as facts that the eggs are laid both in fall and spring, the following questions are to be considered: 1st, whether the eggs laid in autumn hibernate as such, or whether the larvæ first hatch and hibernate while small; 2d, whether those laid in spring are by moths which issued at that season, after hibernating as chrysalides, or by such as issued the preceding fall and hibernated as moths.

As bearing on the first question it is interesting to note that the European species of the genus, so far as their habits are known, hibernate in the larva state. Thus *Leucania lithargyria* Esper, and *L. turca* (Linn.) hibernate as young larvæ, while *L.*

[36] The delay in the printing of this report permits us to add, in this connection, that the experience of 1882 renders it probable that at Washington there are at least five annual generations and possibly a sixth. As already indicated above, we found hibernating worms during all the mild weather of late winter and early spring, and obtained the first moths therefrom (doubtless hastened somewhat by indoor temperature) early in March. Calling this the first generation of moths, sugaring at night from the beginning of May till the end of October, by Mr. Koebele, and experiments in the vivaria, showed quite plainly that a second generation of moths prevailed the latter part of April and into May. The third generation occurred about the middle of June, the fourth from the middle to the end of July, the fifth during the latter part of August and through September. Moths were captured abundantly all through September and October and even early in November, and while we believe that the larvæ produced therefrom mostly hibernate, yet it is extremely probable that many produced imagos, which would form the sixth and hibernating generation of moths.

comma (Linn.) winters as a full grown larva, according to Speyer. Quite a large proportion of our closely allied cut-worms are, also, known to thus hibernate. It would seem, therefore that, in default of direct observation, we have no good reason for assuming that the eggs laid in autumn necessarily hibernate as such. But while these analogies make it probable that the insect may winter in the larva state, all the other facts point to the conclusion that the proportion that so winter, if any, is very small. Instead of abounding in a wet spring when their favorite haunts are overflowed, they would be well nigh drowned out, on the hypothesis that they had been wintering there as larvæ. As bearing on the second question we have certain facts which indicate that some of the pupæ hibernate, the proportion doubtless increasing as we go north. I have myself never had any of the worms remain in chrysalis through June, but Professor Thomas records that less than half of the pupæ which he caged hatched out, and that "only a part are transformed to moths during the season of their larva state."[37] Unfortunately he has left no record of rearing the moths from those chrysalides the following spring, and we do not know to how large a degree the non-issuance of the moths was owing to unfavorable conditions in the breeding cage, which so often affect insects reared in confinement, and which every rearer of insects is so familiar with. But Mr. Otto Meske, of Albany, N. Y., informs me that he once found a chrysalis about the middle of May which in a few days gave him the genuine *unipuncta*, and the earliness of the date precludes the possibility of the worm having been hatched the same spring in that latitude, and renders it almost certain that the pupa hibernated. Of more value still is the earliness of appearance and freshness of most of the moths captured in spring—indicating that they have just come from the ground. These facts might, it is true, be explained by the larva hibernating partly grown, but the Peshtigo experience is valuable here and renders the other conclusion much the most plausible. In fact the hibernation of a certain proportion of the pupæ finds its parallel in numerous other instances in the lives of moths that might be mentioned. Every experienced entomologist is aware that with lots of species the imagos from the same batch of larvæ often issue partly in fall, partly in spring; while I have given instances in previous reports of still greater irregularity. The worms that attract such attention, about the time our wheat is ripening by marching from field to field are mostly full grown. These would naturally soon turn to moths; but it must not be forgotten that they are the earliest developed and that the younger and weaker ones have mostly been obliged to succumb in the struggle for individual mastery, which must have preceded the forced abandonment from sheer hunger, of the original fields where they were born; and that, further, in fields and rank places where the worms are not so numerous as to be obliged to travel, there are individuals maturing for several weeks after the more noticeable hordes have vanished out of sight. As to the hibernation of the moth, having shown that the larger proportion of the moths captured in autumn have the ovaries yet quite immature, it is pretty evident that the insect hibernates in this state, and I learn from Mr. Strecker, that he has in fact, found the moth in February, hibernating under clap-boards at Reading, Pa., while Mr. B. P. Mann, of Cambridge, Mass., has also found it hibernating. It would be unreasonable to assume that such large numbers of the moths as occur in autumn are destined to perish without issue. Moreover, a large number of closely allied moths are known to hibernate, and this mode of hibernation will explain more of the known facts in the insect's economy than any other.

From the foregoing considerations I think we may safely conclude that—taking our whole country with its varied climate—there is no one state in which the Army Worm can be said to solely pass the winter; that, according to latitude and the character of the seasons, there is nothing to preclude its hibernating in any one of the four states in which it exists; that in the same latitude and under the same condi-

---

[37] *Illinois Farmer*, September, 1861, pp. 271, 272.

tions it will even hibernate in different states; and that, finally, the great bulk of them hibernate in the pupa and moth states, the proportion of the former increasing northward.

With our present light upon this subject, and especially with the experience of the past two years, we can revise this opinion, for it now appears that, as in the case of other species of the genus Leucania, and of so many of our ordinary cut-worms, by far the more common mode of hibernating is in the larva state. That the insect does hibernate in the larva state is fully established by the facts already given and by the following summary:

First:—The experience noted by Professor Comstock in the annual report of this Department for 1879, p. 188, viz, the receipt of worms from Tennessee and South Carolina during the months of December, January and February.

Second:—The finding of young worms upon the Department grounds at Washington during the months of December, 1881, and January, 1882—already referred to above.

Third:—The receipt of the worms at this Department in January, 1882, from Clay County, Alabama; the first week in March, 1882, from Lafayette County, Mississippi, Chatham County, Georgia, and Richland County, South Carolina; and the middle of March from Washington County, Missouri.

Fourth:—The finding of a partly-grown Army Worm in the stomach of a blue-bird at Normal, Ills., March 9, 1880, by Professor S. A. Forbes, as detailed in the *American Entomologist*, vol. III (1880), p. 204.

Fifth:—The observations of Mr. Coquillett, already mentioned,—the finding of six partly-grown Army Worms after November 1, under or in shocks of corn in McHenry County, Illinois.

Instances might be multiplied, but our point is sufficiently established. The only argument of any weight heretofore brought to bear upon pupal hibernation, namely, the finding of fresh moths in the spring, has equal weight in favor of larval hibernation. In fact, the instance cited from Mr. Meske, of the finding of the chrysalis and the breeding of the moth at Albany, N. Y., about the *middle of May*, really confirms this view of larval hibernation, as in case of pupal hibernation the moth would undoubtedly have been disclosed at an earlier period.

The evidence in favor of the hibernation of the moth is, as we have shown, conclusive. In addition to the proof cited we may mention that the receipt of the moth from the Southern States during the winter months has been of very frequent occurrence since the commencement of the Cotton Insect investigation, observers mistaking Leucania for Aletia.

Up to the present time there is no evidence whatsoever of hibernation in either the egg or the chrysalis state, though the evidence may yet be forthcoming.

NATURAL ENEMIES.

Hogs, chickens and turkeys revel in the juicy carcasses of the worms, and sometimes to such an extent that, as I have been informed by Mr. T. R. Allen, of Allentown, Mo., the former occasionally die in consequence, and the latter have been known to lay eggs in which the parts naturally white would be green when cooked. The turning of swine and flocks of poultry upon an advancing army of the worms is an old and frequently successful method of riddance. All of the insectivorous birds feed upon the worms. Prominent among them is the Rice Bunting or Bobolink (*Dolichonyx oryzivorus*). So common have the flocks of this bird become in southern Illinois during Army Worm years, that, according to Thomas, it has received the popular name of "Army Worm bird." Toads and frogs come in for their share of this dainty food, while the worms themselves, when hard pushed, will even devour each other.

A large number of predaceous beetles gather about an infested field and greedily feed upon the worms, killing thousands of them. The following list of ten species was published in our Eighth Missouri Report:

Cicindela repanda Dej.	*Calosoma wilcoxi* Lec.
Elaphrus ruscarius Say.	*Pasimachus elongatus* Lec.
Calosoma externum Say.	*Amara angustata* Say.
Calosoma scrutator (Fabr.)	*Harpalus caliginosus* (Fabr.)
Calosoma calidum (Fabr.)	*Harpalus pennsylvanicus* (Deg.)

To this list we may add the following four species collected while feeding upon the worms the present year at Huntsville, Ala., by Mr. Howard:

Pterostichus sculptus Lec.	*Cratacanthus dubius* (Beauv.)
Anisodactylus rusticus Dej.	*Selenophorus pedicularius* (Dej.)

The larvæ of *Calosoma externum* were also found in remarkable abundance in this locality, under stones and logs, devouring the worms which had crept there for shelter during the middle of the day. Some of the most abundant of these predaceous beetles are shown at Plate I, Fig. 8; Plate II, Figs. 1, 2, 4.

The Thick-thighed Metapodius (*Acanthocephala* [*Metapodius*] *femorata*, Fabr.), a large half-winged bug, common in the South, and well-known as an enemy of the Cotton Worm, has also been observed in large numbers the present season in the wheat fields of northern Alabama, feeding upon the Army Worms.[38]

Of true parasites the Army Worm has an unusually large number, and they are by far the most destructive of its natural enemies.

The worms never abound or travel from one field to another but they are accompanied by a number of two-winged flies, which are often so numerous that their buzzing reminds one of that of a swarm of bees.

[38] See note by L. O. Howard in *American Naturalist*, July, 1882.

The Red-tailed Tachina fly (*Nemoræa leucan[i]æ*, Kirkpatrick, Plate I, Fig. 7) and the Yellow-tailed Tachina fly (*Exorista flavicauda* Riley, Plate I, Fig. 6) are known to infest it. Seizing the first opportunity to attach their eggs behind the heads of the Army Worms, these flies are as persistent in their work of destruction as the worms are restless under attack. As many as eighteen eggs of the Red-tailed Tachina are sometimes deposited upon a single worm, but the average is about five. These eggs are almost without exception placed upon the head or thorax of the worm, so that the latter cannot reach them with its jaws. Occasionally, however, they are placed upon the first abdominal segment, and one worm, now in the collection of the Department, carries one Tachina egg upon the third abdominal segment and one upon the eighth. From eight per cent. upwards of the worms in an infested field have frequently been noticed to carry the eggs of these Tachina flies, which, though rendering the most efficient service to the farmer, are not unfrequently supposed by him to be the parent and cause of the worm.[39]

We have observed, since the publication of our Bulletin No. 3 of the United States Entomological Commission, in the case of the Cotton Worm, that, contrary to the former belief, the presence of these eggs on the back of a worm does not necessarily indicate a sure death, although in the vast majority of cases it undoubtedly does. Mr. Coquillett experimented upon this point with the following result: Of sixty-six Army Worms, each bearing from one to five eggs of the Tachina, four transformed to pupæ, from three of which the moths issued. The remaining sixty-two were killed, and from them issued one hundred and four Tachina larvæ, sixty-one of which successfully transformed to flies.[40]

Next, perhaps, in importance to the Tachina flies come the Microgasters, minute four-winged flies, of which there are several species parasitic upon the Army Worm. Their larvæ live within the body of the host, and, issuing, spin small, oval, silken cocoons attached by loose silk to some neighboring object.

Walsh described the most abundant of these species in 1861 under the name of *Microgaster* (*Apanteles*) *militaris*. (Pl. II, Fig. 6.) This species is found wherever the Army Worms are abundant, and its white cocoons, attached to the grass or to the under side of stones and sticks about the field, are sometimes so numerous as to make the ground look whitish in spots. These cocoons are invariably found in small masses surrounded by more or less loose silk. The adult fly is black, with rufous legs. It was the cocoons of this insect which gave the founda-

[39] "In 1875 no less than four of our correspondents expressed a belief that, in the language of one of them, the worms came from a dark-colored buzzing fly about the size of a blow-fly, which is noticed around old stack-yards just before the worms come; and when plentiful, the Army Worm is sure to follow."

[40] For descriptions of these flies see *Prairie Farmer*, vol. VIII; Second Missouri Entomological Report, and Eighth Missouri Entomological Report.

tion for the oft-quoted story of the finding of the eggs of the Army Worm covered by a mass of loose silk, originally published by Shurtleff, in the Proceedings of the Essex Institute, July 2, 1862. One of our correspondents, Mr. M. B. Kerr, of Aurora, Ind., has made many dissections of Army Worms in search of the Military Microgaster, and where he has found the parasites their numbers varied from sixty-two to ninety-six to an individual host. From the cocoons of the Military Microgaster there often issue individuals of a minute secondary parasite—a Chalcid, called by Walsh *Glyphe viridascens*, but which probably belongs to the genus *Tridymus*.

In our Eighth Missouri Report, p. 54, we mentioned the rearing of another Microgaster from the Army Worm, which differed from *militaris* in always having the three basal joints of the abdomen rufous. This we have recently shown[41] to be a variety of *Apanteles congregatus* Say—a Microgaster which is parasitic upon many Sphinges, Bombycids, and Noctuids, and perhaps other Lepidoptera. This species is also parasitized by the *Glyphe viridascens* mentioned above. This latter, by the way, is identical with the *Pteromalus tabacum* of Fitch, who bred it from *Apanteles congregatus* when parasitic upon the tobacco worm (*Macrosila quinquemaculata*).

Another Microgaster which is probably parasitic upon the Army Worm is the *Apanteles limenitidis* Riley,[42] form *flaviconchæ*, as its bright lemon-yellow cocoons are found associated with those of the Military Microgaster in fields infested with the Army Worm.

Finally, we have bred a fourth Microgaster from the Army Worm, belonging to the genus *Microplitis*. It differs from the other species mentioned in being solitary, only a single larva deriving nourishment from the partially grown Leucania larva. This species was also collected this spring at Huntsville, Ala., by Mr. Howard.

A small Ichneumonid parasite, called by Walsh "the Glassy Mesochorus (*Mesochorus vitreus*, Plate II, Fig. 8), was supposed by him to be a true parasite upon the Army Worm, but we have recently shown[43] that it is a parasite upon the Microgasters above mentioned, and it is probable that it cannot be called a true Army Worm parasite.

In the *Prairie Farmer* (Vol. VIII, p. 258) Walsh described another parasite under the name of *Hockeria perpulchra*, which he considered as parasitic upon one of the Microgasters. Only 18 per cent. of the true Army Worm parasites, according to Walsh, perish by secondary parasites.

The Diminished Pezomachus (*Pezomachus minimus* Walsh, Plate II, Fig. 9) is a small, wingless parasite, which, like the Microgaster, spins cocoons in cottony floss on the back of the worm, but places them close together in symmetrical order. This in its turn is preyed upon by a little Chalcid fly (*Smicra albifrons*, Walsh).

"In addition to these small parasites there are a few larger Ich-

---

[41] Trans. Acad. Sci. Saint Louis, Vol. IV, No. 2 (1881).
[42] See Third Missouri Entomological Report.
[43] Trans. Acad. Sci. Saint Louis, *ibid.*

neumon-flies that infest the worm. One, the Purged Ophion (*Ophion purgatus* Say, Plate II, Fig. 5), is a honey-yellow, slender-bodied, waspish insect, with a short ovipositor, the female of which, according to Dr. Packard, attaches her egg, which is bean-shaped, by a pedicel to the skin of the worm; and the footless grub which hatches therefrom does not entirely leave the egg-shell, but the last joints of the body remain attached thereto, while the larva reaches over and gnaws into the side of the worm. I have bred this same species from various cut-worms, and it spins a tough, brown, silken, oblong-oval cocoon."

Another species, a true Ichneumon, which may be called the Army Worm Ichneumon-fly (*Ichneumon leucaniæ* Fitch), was reared from the worm by Dr. Fitch; it is a half of an inch in length and is of a bright rust-red color, with smoky wings, a black breast and back, with a bright sulphur-yellow spot in the middle of its back. This insect Fitch says may prove to be a variety of the *Ichneumon suturalis* of Say, and we believe Mr. Cresson so considers it.

In the article on the Army Worm in the appendix to Harris's Insects Injurious to Vegetation, are figured two parasites—Ichneumonid—but, as there is no accompanying description, it is impossible to determine them.

July 6, 1880, two specimens of a striking looking parasite were bred at this department from Army Worms collected on Long Island by Professor Comstock. The *Ichneumon flavizonatus* of Cresson, for such is the species, is about 15 millimeters in length, black in color, with yellowish legs and face, and the abdomen is striped transversely with four yellow bands.

REMEDIES.

BURNING OLD GRASS, ETC.—That fields which have been burned over in the winter are free from the destructive presence of the worm is a fact in the history of its visitations. But opinion has varied as to the precise effect produced by burning over. Walsh, as we have already shown, always urged this remedy of burning over, thinking that it destroyed the eggs. The next phase was that suggested in our Eighth Missouri Report, where, after showing that the eggs are preferably laid in old grass-stalks or stubble, the inference was plain that the appropriate nidus would be destroyed by the burning.

Now that larval hibernation is established, however, we can readily see that the fires would destroy these hibernating larvæ and prevent the appearance of the moths and of a second destructive brood from them. But we must not suppose that the burning over would prevent *all* appearance of the worm; it merely prevents its appearance in destructive numbers. The moth will, when exceptionally numerous, lay her eggs without concealment and upon plants, such as clover, which the larva does not relish. In such cases of exceptional abundance we may well suppose that the moth will fly into fields which have been burned over and supply them with eggs; but the instances in which this would result in material damage to the crop would be very rare.

"As the Army Worm appears in vast numbers during certain years only, and at irregular intervals, and as this appearance is rather sudden, and seldom, if ever, anticipated by the farmer, burning as a remedy loses much of its importance, except where it is practiced annually; and in view of the benefit of such burning in destroying chinch-bugs and other insects it is to be regretted that the practice of winter burning of fields, prairies, straw-piles, weeds, and other litter and rubbish does not more generally prevail; the destruction of injurious insects by such a system would far outweigh the benefit derived from plowing these stalks and weeds under or leaving them to gradually decay."—[*8th Mo. Ent. Rep.*, p. 55.

PREDICTIONS; METEOROLOGICAL INFLUENCES ON THE SPECIES.—What we still need to know, in order to make the burning over of much avail, is some method of actually predicting the coming of the worms. That meterological changes have much to do with disastrous years is indubitable, yet it is evident from facts we have given that Fitch's theory will not hold. We have shown that he had no practical knowledge of the subject, and that his theory was not well considered. We are also not inclined to admit the truth of Professor Thomas's weather arguments in the case of the Army Worm. We can only say, after a careful review of past years, that all or nearly all of the years of Army Worm abundance have followed dry years, the nature of the year in which such abundance actually occurred having little to do with it. This, however, helps us only so far as to enable us to say that after a year of exceptional drought the worms *may* appear in injurious numbers. We are still very far from saying that after such a year the Army Worm is a necessary consequence, so that for practical purposes we are almost as far in the dark as formerly.

In short, however interesting it may be to speculate as to the weather, no well-informed person will pretend to a sufficient sibylline insight into the future to enable him to act with absolute confidence as to results. The pretensions of a Tice or a Vennor must be classed, in the light of whatever there is of science in meteorology, among the utterances of charlatans and quacks, and whatever the tendency may be for history to repeat itself, so far as weather and season are concerned, the records sufficiently show that there is no absolutely relying upon the weather of the future. Insect probabilities, in connection with meteorological speculation, offer a most inviting field for theory and speculation for those who have few facts to lean upon, but it can never be safe to anticipate for more than two or three months ahead at the most. It is quite possible, from the observed facts during the winter and early spring, to form pretty accurate conclusions as to what may happen the ensuing summer so far as the Army Worm is concerned, and this is especially true when the preceding summer and autumn have been exceptionally dry. This may be illustrated by the following opinion, quoted from an article which

we published in the *Rural New-Yorker* of May 27, which subsequent events have fully justified:

Anent the Army Worm I have obtained many interesting facts during the past winter and present spring, which all go to confirm the correctness of my previous conclusions and inferences, especially those of 1880, as presented to the American Association for the Advancement of Science, viz., that it hibernates principally in the worm or larva state. From the fact that the worm of all sizes has been found throughout the past winter not only around Washington but in various parts of the South, whenever it has been looked for carefully, and from the further fact that the moths have lately been very numerous and active in laying their eggs in this immediate vicinity, I drew the inference, some weeks since, that we should have in most parts of the country serious attacks of the insect during the present year, and sent an item containing this inference to the *American Naturalist* for publication. In confirmation of the correctness of that inference the Department of Agriculture has just received accounts of alarming injury to small grain in northern Alabama and Georgia as well as in Arkansas. If the spring and early summer prove in any way wet (as is likely in the country which suffered so much from drought last year) the precise conditions will recur that have in the past marked all great Army Worm years.

Observations which I have recently been making with one of my assistants, Mr. A. Koebele, fully establish the fact which I inferred to be the case in 1877—that the moth secretes her eggs by preference in old grass and stubble and even in corn-stalks; and this explains two facts that have long since been recognized by practical men, viz., that the worms in destructive numbers are apt to originate from old stacks or piles of corn-stalks, or coarse manure, to which the early moths are attracted for purposes of oviposition. In short, a field will be free from the worm in proportion as it is kept clean of old stubble and straw, and in proportion as it is distant from such, or from neglected pasturage, or low, rank grass inaccessible to cattle.

Believing, therefore, that serious injury now threatens meadows and grain fields from this insect, and that we shall hear of it farther and farther north with the heading out of wheat, and knowing, from experience, that an ounce of prevention is worth a pound of cure, I recommend that farmers generally take the precaution to burn up or plow under at once, wherever it is possible to do so, any neglected meadows, old grass or straw upon their farms; further, to roll the grain in the vicinity of old stacks where these may not be burned. Let me add, further, that one must not be deceived by appearances. The worms may not be visible to an ordinary observer, or even to a careful one, and may yet abound in myriads, for they secrete themselves within old stalks, or folded leaves, when very young, and hide under matted grass or grain when larger. Yet a field that shows none now may in a fortnight be overrun with full-grown worms, so rapidly do they grow.

While, therefore, annual burning in the fall or winter is to be recommended as a haphazard way of reducing Army Worm injury, burning as late as possible in the spring is much more strongly to be recommended, especially during certain years, and following exceptionally dry seasons and special observations that have been made during the preceding winter.

DITCHING; COAL TAR; POISONING.—"The worms may be prevented, as a general thing, from passing from one field to another by judicious ditching. It is important, however, that the ditch should be made so that the side toward the field to be protected be dug under. About every three or four rods a deep hole in the ditch should be made, in which the worms will collect, so that they can be killed by covering them with earth and pressing it down. They may also be destroyed by

burning straw over them—the fire not only killing the worms but rendering the ditch friable and more efficient in preventing their ascent. I have also used coal oil to good advantage, and the worms have a great antipathy to pass a streak of it. Many of my correspondents successfully headed them off by a plowed furrow 6 or 8 inches deep, and kept friable by dragging brush in it. Along the ditch or furrow on the side of the field to be protected, a space of from 3 to 5 feet might be thoroughly dusted (when the dew is on) with a mixture of Paris green and plaster, or flour, so that every worm which succeeds in crossing the ditch will be killed by feeding upon plants so treated. This mixture should be in the proportion of one part of pure Paris green to twenty-five or thirty parts of the other materials named. If used in liquid form, one tablespoonful of Paris green to a bucket of water, kept well stirred, will answer the same purpose, as also will London purple, which has the merit of being cheaper. These substances should, of course, be only used where there is no danger of poisoning stock, poultry, or other animals. Logs or fences over running streams, or irrigation ditches, should be removed, otherwise the worms will cross on them.

"From experiments which I have made I am satisfied that where fence-lumber can be easily obtained it may be used to advantage as a substitute for the ditch or trench by being secured on edge and then smeared with kerosene or coal tar (the latter being more particularly useful) along the upper edge. By means of laths and a few nails the boards may be so secured that they will slightly slope away from the field to be protected. Such a barrier will prove effectual where the worms are not too persistent or numerous. When they are excessively abundant they will need to be watched and occasionally dosed with kerosene to prevent their piling up even with the top of the board and thus bridging the barrier. The lumber is not injured for other purposes subsequently."[44]

ROLLING; FENCING; ROPING.—Where the crop of a field has been completely destroyed by the worms, the plan of killing them by heavy rollers has been tried. This, however, is an expensive remedy and is not as satisfactory as might be supposed. Experiments on Long Island in 1880 proved that even where the ground was level the rollers soon became irregularly covered with mud composed of earth and of the juices of the crushed worms, so that the effect was much the same as if the ground had been uneven, and many worms escaped in consequence.

The remedy of "drawing the rope," as it may be termed, was practiced as long ago as 1770, and is described, under the head of "Past History," in the quotation from Rev. Grant Powers. Although this remedy has been practiced from time to time since then, we are not aware that any other account has been published. This spring it has been tried with good effects at Huntsville, Ala., and by Mr. J. W. Sparks,

[44] Quoted from previous articles by the author.

of Murfreesborough, Tenn. We quote from a letter from this gentleman describing his method:

The Army Worm is making such inroads upon the wheat crop and other crops here, in middle Tennessee, I thought I would write you and give the process I have for ridding the wheat of these vagabonds. I take a rope about 60 feet long and cause two men to walk through the wheat field, dragging the rope over the wheat. By this means you can go over a large field of wheat in a few hours. The rope, dragging over the wheat, shakes the worms off on the ground, and they curl up and lie there half an hour or more—seem to be mad about it—and then begin to move about hunting something to eat; but the larger ones are unable to climb the wheat stalks with all the blades off, so that you get rid of the larger ones the first time going over, and the smaller ones can be shaken off so often that they cannot hurt the wheat. If you will make known this simple plan to the sections where the worm is at work the people can yet save their wheat. I am satisfied I will save mine. I am going over my whole crop twice a day. My wheat is looking splendid, and if I succeed in whipping the worms I will make a large yield. You shall have full reports at the proper time.

In regard to this remedy it may be well to say that while tolerably efficacious when the worms are not present in overwhelming numbers, or when the crop is far advanced and the stalks are large and tough, under opposite circumstances it will be of little avail, and it will always be a question whether the portion of the crop saved by this means will be worth the great expenditure of time and labor which this remedy calls for.

As a fitting sequence to this general statement of the more interesting practical facts connected with the Army Worm, we introduce such letters and extracts from correspondence as are of sufficient interest for publication, and also, as intimated at the outset, a valuable account of the insect in New Jersey in 1880, by one of our esteemed correspondents, Rev. Samuel Lockwood.

REPORT OF OBSERVATIONS UPON THE ARMY WORM, 1881.

WASHINGTON, D. C., *August* 7, 1881.

SIR: In accordance with your verbal directions, and the written order of the Commissioner of Agriculture given me July 23, I started on the morning of the 24th for Chicago, Ill. Arriving there on the morning of the 25th, I spent the afternoon in interviewing the editors of the *Farmers' Review* and *Prairie Farmer* with regard to the extent of country over which the worms had made their appearance, and in ascertaining the most profitable spot in the State to visit. I started on the morning of the 26th for Raub, Ind., a small station on the Kankakee line. Arriving at Sheldon, Iroquois County, Illinois, however, I was induced to stop by the accounts given by men at the station as to the abundance of the worms. I spent the whole of the 26th at Sheldon, and on the 27th went over to Kentland, Newton County, Indiana, where great damage was reported, and where I spent the morning in the field. On the evening of the 27th I returned to Chicago, where I found a letter from Prof. W. A. Henry, of Wisconsin University, in answer to a telegram I had sent him on the 25th asking about the northernmost appear-

ance of the worms. His reply was that they were reported near Madison, and that the northernmost point from which they had been reported was Waupun. On the morning of the 28th I started for Madison, reaching there in the evening. The next morning I ascertained that the Army Worm rumor in that locality was a false alarm. *Heliothis armigera* in sweet corn had been taken for Leucania, and the work of Lachnosterna in a few meadows had been supposed to be the work of the Army Worm. Learning from Professor Henry and the editor of the *Democrat* that the only points from which there had been newspaper reports of the worm in Wisconsin were Oshkosh, Whitewater, and Waupun, I obtained the address of a well-informed man in each place—one who would certainly have heard of the Army Worms had they made their appearance—and telegraphed to each for absolute information as to whether the worms had been seen in his locality, and the answer was in every case contrary to our expectations. Feeling quite certain, therefore, that the worms were not to be found in any number in the State of Wisconsin, I took the night train back to Chicago on the evening of the 29th, occasionally getting off at a station and making inquiries about the worms. I learned on my return to Chicago that the worms had been reported as doing a great deal of damage at Kalamazoo, Mich., so I bought my return ticket via Michigan Central and spent a night at Kalamazoo. The most diligent inquiry, however, on the spot failed to find me a man who knew of their presence.

EXTENT OF COUNTRY INJURED.—I failed, therefore, to find the worms in any other locality than in northeastern Illinois, and across the border line in Indiana, and I am strongly inclined to believe that, outside of a belt embracing portions of Lasalle, Kendall, Grundy, Will, Kankakee, Iroquois, Livingston, and Ford Counties, Illinois, and Newton, Benton, Jasper, Warren, and Tippecanoe, Indiana, the damage was not very great, although the reports from central and western Illinois were quite alarming. From what I could learn of the reported appearance in Iowa, I believe that some other worm has been mistaken for the Army Worm in that State.

CROPS INJURED.—The oat crop seems to be the only one which has been appreciably injured. Some little damage has been done to corn, especially young sweet corn, and in some cases slight damage has been done to flax and millet. The timothy on pasture lands has also been somewhat eaten.

AMOUNT OF DAMAGE.—The damage to oats has in many cases been very severe. I saw fields of several acres which were not considered worth harvesting. At one place, seeing a steam thresher at work, I made inquiries, and found that they were averaging about two bushels to the load, when the proper amount should have been fifteen bushels. Dr. Bush, of Sheldon, states that, to the best of his judgment, the crop in Iroquois County has been damaged not to exceed ten per cent. This was indorsed by most of the men I met who were not farmers, the latter

placing the damage at from 25 to 50 per cent. The total amount of oats in that part of the State will not fall behind the crop of last year, owing to a much greater acreage. Many farmers have put in oats on account of the failure of winter wheat. In the southern part of Newton County, Indiana, the damage done was very great. Mr. Kent, of Kentland, who owns several farms, says that while his individual crops should have been 50,000 bushels, he would be happy to realize 10,000. He says that the loss in Kentland township will easily be 75 per cent. of the crop; but at the same time realizes that this is local, and says that the crop of the State as a whole will be immense.

THE PREVIOUS SEASON.—The persons interviewed seemed to be unanimous in the opinion that the last season was very wet during the early part, and that this was followed by a very dry late summer and fall. Last winter was, as all over the country, a very severe one, while the winter before was remarkably open. The present season has been a very favorable one, the spring, however, being rather dry.

THE PREVIOUS CROP.—In fields which were worst injured I always took pains to inquire concerning the previous crop, and found considerable diversity. In two cases it had been corn, in two oats, in one flax, in one barley, and in one prairie land. In several cases also it was winter wheat which had been plowed up in April. The damage in all these fields this year was equally great.

METHOD OF WORK.—The method of work in oats is the same as in timothy and wheat, as described. The fruit-stalk is stripped of its leaves, and the head is cut off and falls to the ground, where it is usually eaten to a greater or less extent. Some farmers have taken advantage of this fact, and have turned in their swine to feed upon the fallen grain, and at the same time they undoubtedly destroy many worms and pupæ.

No marching whatever has been noticed. The worms appeared simultaneously all through the fields, and having plenty of food there was no occasion for going farther. This fact has given rise to an opinion among many farmers that this is not the Army Worm but a cut-worm that is always present in the fields. This fact also puts an effectual estoppel upon the use of the old remedies, and there seems to be no way to destroy the worms in the fields without a sacrifice of the crop.

FACTS BEARING ON NUMBER OF BROODS.—That the brood damaging oats this year was at least the second, and, in case of larval hibernation, the third, seems most probable. The injurious brood in Illinois has been usually in June, the worms pupating about the middle of the month, and the moths appearing from the 20th to the 30th of the month. In the places visited this year the worms were first noticed from the 12th to the 15th of July, and at that time most of them were of the size of a "small straw."

In one instance several empty egg-shells of Leucania were found in the vicinity of a last winter's fodder stack. They were in the fold of one of the *basal* leaves of the stalk. These, from their position, may have

been laid by the first brood of moths, though from the known ovipositing habits they may equally as well have been deposited by the second moths.

In the same locality I found, by digging, the remains of two empty pupæ, undoubtedly Leucania, which certainly belonged to a previous brood.

AN ACCOMPANYING CUT-WORM.—In the fields, among the Army Worms, were large numbers of an accompanying cut-worm, in the evident proportion of about one of the cut-worms to five Army Worms. The size of the former was about that of the latter, and the color a nearly uniform dusky brown, with transverse lateral stripes of a darker color. They transformed to slender pupæ, light brown with dorsolateral longitudinal, pinkish stripes.[45]

NATURAL ENEMIES.—Several larvæ of a ground beetle (probably *Calosoma scrutator*), large, black, horny, and active, were found destroying the worms at a great rate. I have been unable to breed them, the only pupa obtained dying in the box. In order to ascertain the amount of good which these larvæ do, I placed my largest specimen in a box with 15 full-grown Army Worms, after starving him for a day. In two hours I opened the box and found that he had killed every one of the worms, but had sucked dry but two.

The small, white cocoons of an Ichneumonid[46] were found in enormous numbers, attached to the oat stalks, in the axils of the corn leaves, upon the surface of the ground, and under clods of earth. Often upon lifting a clod of earth the black loam appeared light gray from the abundance of these cocoons. They were usually found in small masses, attached side by side, with a little loose silk around the mass. I saw large numbers of a large reddish-brown ant tearing these cocoons open and feeding upon the pupæ.

A secondary parasite was bred from these cocoons, which seems to be the *Mesochorus vitreus*, of Walsh.

In one instance, in a corn-field belonging to Mr. Corlett, of Sheldon, the worms were observed to be extensively infested by a Tachinid from the eggs upon the thoracic segments. Not a single worm was found in this field which did not bear one or more eggs. I have since bred from one of these larvæ a small specimen of what appears to be the common *Nemoræa leucaniæ*, of Kirkpatrick. I also observed in the act of ovipositing an Ichneumonid about 15 millimeters in length, rufous in color, with white-banded antennæ, and wings not extending to the tip of the abdomen; but I was unable to capture it.

Respectfully submitted,

L. O. HOWARD.

Prof. C. V. RILEY,

Entomologist, United States Department of Agriculture.

[45] This proved to be *Agrotis c-nigrum*.—C. V. R.

[46] *Apanteles congregatus*.—C. V. R.

CORRESPONDENCE ANENT THE ARMY WORM—SPRING OF 1882.

I send you the inclosed communication from the Huntsville correspondent of the *Chattanooga Times* in relation to an invasion of the wheat crop in this vicinity by the Army Worm. I reconnoitered the invaders yesterday, and witnessed with feelings of much sadness the devastations already wrought by them on Stevens' farm. I captured and examined some of them. It is the Army Worm described in the Agricultural Report for 1879, page 187, and the same I think that appeared here in 1861. * * * The insects are of different ages, and it is to be apprehended that there will be successive crops of them. * * * Upon examining an oat-field yesterday, in company with Mr. White, I found multitudes of very small worms concealed under the oats sown this spring. It was about half past 3 p. m., and the sun shining. They will doubtless destroy it. Mr. Bedermann's oat patch, near Stevens' wheat-field, has been completely destroyed. Some of the larger worms in Stevens' field show that the Tachina parasite has been operating upon them. I never saw a more promising wheat crop than Stevens' before this invasion. White said to me that in the beginning of last week he would not have taken $2,000 for his own wheat crop; that he does not now expect to reap anything from it. I hear of this insect in the neighborhood of New Market and Whitesbury.—[S. D. Cabaniss, Huntsville, Ala., May 2, 1882.

An interesting feature of the appearance of the worm in Alabama in May is contained in the following letter to Mr. Howard upon his return from the investigation made at Huntsville. The insect confounded with the Army Worm is the clover-hay worm (*Asopia costalis*):

SIR: While you were here a few days since, investigating the phenomena of the worm in wheat, I had the pleasure of an introduction and a brief conversation with you, and take, therefore, the liberty of stating to you a curious phase of the worm. Mr. J. G. Baker, living here in 1881, produced clover hay—about two tons per acre—on rich land near the corporate limits of Huntsville. The hay was cut, cured, and placed in the mow—about eight tons. He used down to about two tons, and a few days ago, on taking out and delivering a load of hay, after taking it off the wagon, discovered on the floor of the wagon innumerable worms about one-half inch long, dark or greenish-brown in color. He then returned and found on examination of the hay-mow countless numbers of these worms—also what seems to be a kind of web spun in the *débris* at bottom, which had multitudes of eggs half the size of a mustard seed and black in color. This was about the first of May, and the worms have now disappeared. It seems to be a theory that these worms are bred in clover-fields, and this finding them in clover-hay would seem to establish their habit of depositing their eggs on the clover-stalk in the field, in this case carrying them over to the next year and hatching then. This hay was cut about June 1, 1881, and taken out about May 1, 1882. This theory struck me as possibly inconsequential, but of enough curiosity to write you.—[L. W. Day, Huntsville, Ala., May 13, 1882.

The Army Worm is making severe inroads upon the wheat crop and other crops here in middle Tennessee.—[J. W. Sparks, Murfreesborough, Tenn., May 20.

The Army Worm has commenced work. Is it safe to use London purple?—[Saint Louis, Mo., May 24, 1882.

I send you by this day's mail, specimens of a caterpillar which is doing great damage to the wheat in this locality. I have been unable to find out how far-spread it is, but hear of it in the northern parts of this county and also in Nelson County. It attacks and eats the blade of the wheat (so far I do not see that they have hurt the heads), and I find many stalks broken off.—[H. A. K. Murray, Warren, Albemarle County, Virginia, June 8, 1882.

Doing considerable damage to oats near Uniontown, D. C.—[L. J. Barber, June 15, 1882.

The Army Worm is playing great havoc in this section of the State. All the late wheat is being destroyed by them wherever they have appeared. Many fields of grass that were most luxuriant a week ago, look now as if a fire had swept over them. Cornfields, wherever they have touched, have been entirely destroyed—too late now to plant over. Clover alone seems distasteful to them. Oats, corn, orchard-grass, timothy and wheat they delight in. We have never had them before, and don't know what may be their duration. They appeared about a week ago and are increasing in numbers most rapidly.—[Robert Beverly, The Plains, Fauquier County, Virginia, June 19, 1882.

Inclosed find tube containing specimens of Army Worm, which has occasionally infested this country ever since its first settlement. The first serious injury was done in June, 1825, when it appeared in some wheat-fields and meadows, and after eating the heads and blades of the timothy, and partially stripping the wheat and rye of their blades and beards, with little injury to the grain, it moved disastrously upon the green corn and oats, eating down the corn and completely beheading the oats. * * * This year they appeared in the barley about the 10th of June, and have done great damage by eating off the straw just below the head, and a few days later appeared in the wheat and timothy all over the country to a very alarming extent; but just as they had got fairly to work, on the night of the 14th, the whole country between Somerville and Indianapolis was visited by very disastrous storms and floods, which seem to have caused them to suspend operations, though not to entirely disappear.—[M. B. Kerr, Aurora, Dearborn County, Indiana, June 19, 1882.

My observation of the locality of the Army Worms laying their eggs has been this: In the early spring the moth has not the activity it has later in the season, and the greater part of the eggs are laid in the splits of broken straw and in the foldings of the leaf-sheaths, mostly covered or secreted; but in the layings of early spring I have found the eggs most abundant in the angle made by the leaf-sheath when torn from the straw at the joints of same, and *not secreted*. I do not think the hibernated moth would show its specific characteristics as much as

those that have undergone their changes and lay their eggs in a higher temperature. I have noticed that a high temperature has a good deal to do with the activity of the moth of the Army Worm.

The migration of the worms is not always in quest of food, though at this period, like all worms of this class, they are ravenous. There has been a migration into a field in this vicinity which I have closely watched. Before leaving a wheat-field, where there was an abundance of food, the worms showed an uneasiness similar to that shown by the silk worm before spinning its cocoon (moving the head from right to left). The first move was into the blue grass (*Poa pratensis*), and then across a traveled road into a field of corn partly plowed over with the rows in the same direction the worms were going. They ate for 10 to 15 rows every bit of corn on the *plowed ground* and but little on the unplowed. As they advanced the destruction was less and less, nearly stripping the leaves of the 30th and 40th rows, and entirely leaving the unplowed ground. These worms were of a very uniform size—full grown.

To-day I examined a few hills of corn on the boundary of their eating as they were congregating around the hills of corn in their migration. I looked there first, and at a single hill found 18 chrysalides under one small clod. I think this horde of worms left this wheat-field because it was unfit for the change from larva to chrysalis, not offering any shelter, as the ground in the wheat-field was smoothly beaten down by rain and was very hard. Where food is abundant and shelter can be found for the larvæ to undergo their changes, they will not migrate, but from either a shortness of food or unfavorable locality for chrysalides they will move. If the worms are full grown the damage will be but little compared with the migration from a shortness of food by the worms of a small size.

In the shape of the ditch, to defend a field against their incursions, there has been in this locality quite an improvement over the old undercut ditch. It is made by dragging along the ditch a ditching-gouge, such as is used in laying 3-inch tile in the angle of the ditch.

The cutting is on the side you wish to defend, this half-round cut being made by a horizontal motion, leaving a smoother surface on the half-round than can be done by undercutting with a spade, and I have never seen a worm pass the upper angle in this pattern of ditch.—[J. C. Andras, Manchester, Scott County, Illinois, June 22, 1882.

My brother, Alfred R. Swann, who resides on his farm in Jefferson County, Tennessee, writes me that Army Worms have appeared in vast numbers and are now destroying his grain and grass crops. The same thing occurred last season, and as this farm is a very valuable one—nearly one thousand acres, a large part of which is river-bottom lands—the loss involved will amount to several thousand dollars. (It is known as the Eagle Bend Farm.)—[James Swann, New York, June 30, 1882.

ACCOUNT OF THE INVASION OF 1880 IN NEW JERSEY.

BY REV. SAMUEL LOCKWOOD, PH. D.

"Caterpillars, and that without number."—*Bible.*

It was the first day of summer, 1880. A long, parching drought had prevailed, and one felt like choking in the hot and dusty air. Although Flora's brightest month, "when June's red roses blow," the bees were almost starving in their hives, so few and poor were the flowers. The stage, on its way to the station, several miles off, picked me up at a farm-house. A strange being, hatless and shoeless, was leaning against a fence on the road side.

"That's poor Daft!" whispered the driver, in a compassionate way, as we drew near. The man seemed about thirty-five, and had a harmless, half-dazed look. Having taken a step or two into the road, he accosted us in a solemn manner, causing a momentary halt.

DAFT. Have you seen the Army Worm?

JEHU. Nary a worm, Daffie!

DAFT. Oh, but he's come! He's down the road about half a mile, and's committing desolation most promiscuously. There wasn't one there yesterday. But this morning, lo! a great multitude which no man can number! It's all very mysterious, the palmer worm and canker worm. His great army! Maybe that's why nobody can tell us where they come from and what becomes of them. I'd like to know if it *is* all past finding out.

JEHU. That's too deep for me, Daffie. G'e'long, ponies.

Having started his horses again, the driver told me that "though feeble-minded elsewise, Daft was real powerful on Scripter."

I had that morning at an early hour been watching the conduct of an army of *Leucania unipuncta*, the very one to which Daffie referred so mysteriously. In truth, actuated by the vastness of this invasion of the Army Worm, I was then on a season's observations, which it is proposed to give with some fulness of detail; and perhaps we may thus true answer make to the wise questions of that innocent.

The army above mentioned had just made complete havoc of a clover-field. They were bred from eggs laid in a low-lying, last year's rye-field adjoining. After but partially eating the grass in this old field, it was abandoned for the more succulent and tender clover and grass in the next field. The very unusual heat and drought had been too much for the young worms, having rendered too tough the grass in the field where they were hatched.

In the new field the clover and the grass in its shade were much more comestible. This field was completely devoured—not a spear of grass or leaf of clover escaped the invaders. Nothing but naked clover-stalks with empty heads remained—even the headlands were thoroughly cleaned up. A low but distinct and unpleasant crinkling sound accom-

panied the feeding. As if actuated by one impulse the whole army made straight for a wheat field across the highway. The plowing of a trench on the far side of the road intercepted their march. Two men with spades cut a clean, perpendicular face on the side of the furrow next the wheat and a series of little pit-falls in the trench at intervals of about 50 feet. This completed the trap. The caterpillars, wearied with useless efforts to climb the straight side of the trench, would crawl along until they fell into the little pits. Myriads of ants beset them, sucking out their juices, which, with the heat of the sun, soon destroyed them. They cannot endure direct sunlight but are essentially night-feeders.

If uninterrupted, their march to the new feeding grounds would have been accomplished ere the sun was well up.

The time in which the Army Worm did its chief mischief in Monmouth County, New Jersey, was from about the close of May to about the 20th of June. The first observation of real mischief being done was May 28.

During the above time my duties led me to ride over the entire country on official business with the teachers and school-officers. Thus opportunities were afforded for observation and inquiry such as a naturalist could not afford to neglect. I had supposed the aliment of these insects to be restricted to the *Gramineæ*, that is, the grasses proper and the grains and Indian corn. Hence, surprised at the thoroughness with which they had eaten up that field of clover, on the spot I took it for an original observation of an exceptional habit; but, upon looking into the Riley reports, I found similar facts on record. I soon ceased to regard this habit as at all exceptional; for, so far as Monmouth was concerned in 1880, clover-eating by the Army Worm was the rule and not the exception. In fact, I could not learn of one instance of their presence in which the clover escaped. The following from a letter by a teacher is to the point:

On the farm of Charles Allgor, at New Bedford, in passing from his wheat-field to his oat-field, the worms had to cross a strip of sward composed of timothy and red clover, of three or four years' standing. They took everything clean. They also ate the young clover in the bottom of the wheat-field, killing it entirely. In a mixed sward of George Newman's, the teacher, they ate the clover as well as the grasses, leaving nothing but the stalks. They also ate the clover on the farm of Albert King, at Green Grove. They did not make a specialty of clover, but they ate it without being starved to it. They ate both the clover and timothy in a mixed sward of James Allgor's. They ate Mr. Allen's oat-field, then went over to his sward of grass and clover and finished that off, too.

Other correspondence might be cited to the same effect, but I have none which states the facts so concisely as the above. Some of the farms here mentioned are miles apart. But it will appear further on that, when forced into straits for food, this Army Worm is almost omnivorous.

With no special call to examine his young grass-fields, the farmer sometimes got his first alarm at sight of the disappearing clover. In fact, wherever the worms appeared in force, the grasses, clover, and

Indian corn were completely destroyed. A friend lost forty acres of newly-sown grass, with a large part of the old meadows; a very serious score here for one man, as with us "Hay is King." Let me instance a forty-acre wheat-field of his of which the worms took possession. The wheat when harvested proved a good yield, for it had got out of milk when the army made its inroad. The straw was not hurt, although the worms had climbed every stem up to the head; but straw and ear were nearly ripe. It was different, however, with the low and late-grown stools. These they crept up, and ate through the thin, green neck of the plant, cutting off the nubbin-ears, which fell and thickly covered the ground. If the outside of the straw was not too hard, the worm would then literally skin it, eating downwards. They would eat these nubbin-heads occasionally before cutting them off; but this was only when they proved to be soft; that is, those ears whose growth had been backward.

In this wheat-field the young grass and clover were all eaten up and the headlands cleared off. Every weed, too, was cleaned up. Even that bitter nuisance, the Ragweed (*Ambrosia artemisiæfolia*), was all devoured. With us after harvest the Ragweed takes possession of the soil; but as this weed makes its appearance in summer, the spring timothy and clover get the start and keep this weed under. The fall succeeding the harvest above presented the singular spectacle of a stubble-field without a weed. It was sheer nakedness itself. On another farm, having consumed the grass, the worms took possession of a strawberry-field, eating both leaves and the unripe fruit. Riley gives an instance in which, when driven into straits, these caterpillars ate an onion patch. We must then conclude that the larva of *Leucania unipuncta* is well-nigh omnivorous. Doubtless when its food is tender and in no stint, like the Lord Mayor's fool, it knows what is good and is much more dainty.

The number of worms in that forty-acre field was simply fearful. In the parlance of the spectators there were "millions and millions." The squirming mass and the crinkling sound of their feeding were especially repulsive. But few dared to enter the field. In truth, strong men turned pale from nausea, so loathsome was the sight. It really seemed that nature was smitten with a plague of crawling vermin.

What governs the direction of travel of these worms? Do they smell the new food from a distance? I think they do, for they cross naked roads with unerring directness to the object sought. The great army in that wheat-field, having finished their havoc, divided into two parts: the one left on one side and entered a timothy-field—the other left the foraged land and marched straight across the road and took possession of a corn-field. Having ruined the timothy and the corn, the great army disappeared, as was remarked, "as if by magic!" But the trick was very simple; they had entered the ground to assume the pupa state. The notion prevails that the worms move for a certain point of the

compass. Here the phrase was "They moved towards the sea," that is, south; but in another part of the county the movement seemed north.

Many years ago I saw an army moving west, but the Greeley precept was rife at that time. I attach no importance to the above, my belief being that the insect, attracted by scent, in which perhaps the wind plays a part, moves simply in the direction of food. A point of greater consequence is the *time* of the first movement. From a number of observations I believe the time is about seven days after the hatching.[47] When first hatched they are so small that the damage they effect is slow, and their feeding is restricted to the tender parts of the grass. After this comes the first march when they are ravenous enough to clean up as they go.

That was a triumph of painstaking patience and admirable skill when Riley cleared up the mystery of the origin of the Army Worm. Nor can I forget my own delight when, in his laboratory at Saint Louis, in June, 1876, he showed me the live insects which he had raised from the larvæ; nay, more, right before my eyes was the mother *Leucania unipuncta* laying her eggs in the axils of dry stubble and green grass. For science that was a grand discovery. Still more's the pity how few farmers make of it "a coigne of vantage." Nay, to some good husbandmen do we not seem in these searchings to tamper profanely:

> And take upon 's the mystery of things,
> As if we were God's spies.

These appearings are regarded as almost miraculous. Says the perplexed rustic: "They come in great armies—and all of a sudden—and as suddenly disappear." Or, as Daffie said, "There wasn't one there yesterday, but this morning, lo! a great multitude which no man can number." Friends, this is a delusion. They were there yesterday and several days. They do not come suddenly. You do not observe their coming, you only see them when they are on you in great numbers. Watched from the eggs their life-career is that of other caterpillars. The following should enable one to observe them at their starting point and to stamp them out at the beginning:

First. It is important to know *when* to look for the laying of the eggs. Of course much depends on the nature of the season. With us it is usually the first week in June, but in 1880, for reasons already mentioned, the laying was not later than the 20th of May.

Second. Where should we look for them? Thanks to Riley, we know how the eggs look and the part of the plant where they are laid. The farmer, however, needs, if possible, to know just where on his farm he should look for the infested plants. I think generally the grain-fields are preferred by the moth when seeking a nesting place for her eggs. But if the weather be favorable, and the young clover and grass in the best condition, she will also be found laying in the young grass of last fall's stubble-field and in old meadows. In this case we should look for

[47] It is in reality generally somewhat later.—C. V. R.

the highest or closest grass—that growing in moist places, and notably those little hummocks or tussocks caused by the droppings of cattle. If heat or dryness affect their food they will select the grain-fields as affording more succulent food, besides better shelter and shade. Let me instance some careful observations made on four farms, three of which were near together, but the last one to be mentioned was about two miles away. On one was a wheat-field, which covered the site from which certain stables had been moved the year before. Another part of the field lay low, and received the "wash" of the higher ground. On these places the wheat grew thick and high; in fact, too luxuriantly, for it became badly "lodged." These two spots were shady, and the food was sweet and tender. There were no other such spots in the field, and these, and only these, were chosen by the moths in which to lay their eggs.

Doubtless very many moths selected these spots, for here the worms were bred in great numbers. These spots were soon eaten off clean—clover, and grass, and wheat leaves, and heads—for in these places the wheat ears were still green and tender. From these nesting spots they spread, a voracious army, over the whole field, clearing up everything that had not become too hard to eat.

On another farm close by was a field of wheat which had received peculiar tillage. It belonged to a Mr. Bodee, a very intelligent amateur farmer, whose clear observations have been of substantial service to me. He holds that wheat should not be crowded, and should be worked with a cultivator, much as we do corn; that room and encouragement should be given each plant to enlarge itself by stoles; that one well stoloned plant is better than several plants forced to occupy the same surface of ground. In sowing, the field was drilled only one way, and every third drill was left seedless; and in cultivating, some of the teeth of the implement were taken out, so that it could straddle the double rows. In this way the field was gone over, both in the autumn and in the spring. There were but three little spots where the wheat had lodged, all of which were breeding-places for the worms, from which, after eating them off, they spread over the field, but seemed to be comparatively harmless; for the tillage mentioned let in the sunlight and quickened the ripening of the grain. It was noticed here that the birds, having more wing-room, were quite busy feeding on and carrying off the worms, a fact not observed by us in any other wheat-field. Perhaps the cultivator had mellowed the ground, for the worms, during the hot sunshine, buried themselves in the cultivated space and were easily unearthed by the birds.

In a field on another farm the wheat was somewhat thin; but on a spot where a compost had lain, the wheat was rank and thick. There the worms bred, and, after devouring their nesting place, they spread over the field.

The fourth field of which the particular facts must be given, is that

forty-acre wheat-field already instanced. The sowing took at least twice as much seed per acre as was used by Mr. Bodee's method. It was drilled in one direction, and then drilled across at right angles. This secured a crowded growth. During the summer preceding the autumn sowing, the field had been used by a horse dealer to pasture a large drove of horses. Of course their ordure fell everywhere; but in many places where the animals had stood in groups the droppings had fallen in quantity. Here I must recall an acquaintance once had with a farmer's boy, named Ned. He had a way at time of wheat-sowing of putting a shovelful of manure and an extra dropping of seed in a few spots in the field to make what he was pleased to call "King hills." And it was easy telling where the lad and his shovel had been, for Ned's "King hills" always outranked the rest of the field. And it was similarly with that big wheat-field. It was a splendid sight, the close, dense growth, and high over all, in many places, those stately "King hills" were conspicuous. Now comes the notable fact; every one of these spots was chosen as the nesting place of myriads of the mother moths, for the number of eggs laid in them was enormous. These spots were to the Army Worms shelter, shade, and food, but so crowded was each of these larval communities that they soon ate themselves out of house and home. Then came an immense dispersion. From every "King hill" went forth a hungry band into that grand foraging ground. The wheat, standing so close, had by its shade kept the undergrowth protected from the drought; and now it sheltered these marauders from the sun. It was but a few days before that these foraging bands, by their spreading, had all met and made up a vast famished army, which, driven into straits, must now devour every comestible thing or starve. The observed occupancy of the field was seven days; that is, from the time of the dispersion of the foraging army to the time when it left. It was quite common to hear it said that a certain field was eaten up in a day: But such people "take no note of time."

Leucania, the parent of the Army Worm, ranks very respectably among the Lepidoptera. She is one of the owlet moths, and her owlish capacity for natural selection impresses me profoundly.

> Nature is fine in love: and where it's fine
> It sends some precious instance of itself
> After the thing it loves.

I find so much precision in insect wisdom, such a knowing method, even in the propagation frenzy. And I think Leucania's conduct is in point. True, there is no bird-like brooding over her trust. Let us get out of the laboratory and watch her where, not hampered by the inquisitorial restrictions of the breeding-cage, she has Nature's airy freedom, and

> The world is all before them, whence to choose
> Their nesting place.

And this maternal moth shows such good mothering in her choice. The knowledge of this nicety of her selection of a nidus is of great eco-

nomical value. Compare her restriction with the flitting habit of her queenly relative, the Hawk-moth—*Macrosila quinquemaculata*—parent of the great potato worm. Almost with a shudder one remembers that terrible invasion of Monmouth, when the potato-fields were ruined as if by fire, and the wagon wheels reeked with green dripping gore as they entered our villages. This moth deposits her eggs on the under side of the potato leaf, but only one or two, or at most a very few, on each plant; hence the distribution is pretty uniform over the entire field.

Though it may seem above that the parent of the Army Worm has fair intelligence, we may not think so well of her larval offspring. That beautiful lawn of Hollywood, at Long Branch, was invaded by them. The emerald sward was swept as if burnt. When any of the worms came against a tree they went up it, passed over the crotch, then descended at the other side. Twelve or thirteen years ago a corner of our country was visited by the Army Worm in large numbers. Having stripped one field they marched for the next, but were intercepted by a small running stream. There is no "turn back" to this singular worm. On came this great automatic army—no halt—until, crowded forward, a compacted mass was urged on to the water to serve as a living pontoon, over which the army passed and took possession of the new foraging ground. This crossing of running water has been noticed by Mr. Riley.

Monmouth is an old county, and the farms generally have been much reduced in size by frequent divisions. Grain and grass fields run from ten acres to forty, but the latter figure is very high. As we have described, each field from a few nesting spots would originate an army. Some of these infested fields were miles apart, the intervening territory being exempt. I got returns of twenty of these armies in one township. There surely could not be less than one hundred in the county. They seemed to have a penchant for the best farms.

LET US RECAPITULATE.

1. We can localize the breeding places. The mother moth selects the thick and shady spots in the grain fields and meadows as the right places in which to lay her eggs, thus securing for the larvæ shelter and tender food.

2. An army is made up of bands, each band having its own breeding spot, and these spots are centers of dissemination. When these nesting spots are eaten off the bands spread, traveling in the direction of food, thus uniting, when, so to speak, the clan relation is lost. They now form one hungry and marauding army, set in one course and impelled by one impulse. It is at this point of their career that they are generally first noticed, and the averment is made, "They have come all of a sudden."

3. A thin tillage is adverse to the worms. It makes the conditions

of life harder for them, less shade, more heat, earlier ripening, and quicker toughening of grass and grain, and greater freedom for the birds.

WHAT SHOULD BE DONE.

4. Till uniformly, and not too close. You may get less wheat, but you will get better, and the worms will fare worse.

5. Try to find out where the caterpillar originates. Beginning early in May, watch the thick spots and the damp places in meadow and grain. This inspection is especially called for if the winter has been mild and the spring is warm. As described by Riley, the eggs are very small and round when first laid, of a glistening white, but becoming yellowish. They are laid in stringy groups containing from five to twenty eggs. They should be looked for in and near the axils of the leaves; that is, in the spout-shaped parts of the blade, near the stem. In this hollow of the leaf the eggs are glued, and sometimes the two edges of the leaf are so drawn together that the eggs look like a white streak. Should you find the eggs, if in quantity, it might not be practicable to attempt collecting them, but you have found a breeding spot, and it is now possible, and without injury to the grain or grass at this early stage, to extinguish the worm with a weak solution of London purple or Paris green. If the spots are small they could be cut out with a sickle and fed to stock. If the eggs are hatched the crinkling sound made when feeding, which is in the early evening and just before the morning dawn, will to a good ear betray the presence of the larvæ.

Our Army Worm is *Leucania unipuncta*, for there are other caterpillars which are wrongly so called. The moth is 45^{mm} or about $1\frac{3}{4}$ inches in expanse of wing, and 24^{mm} or about $\frac{7}{8}$ inch in length of body. The color is very plain, being a reddish-brown or cinnamon, with a double white spot or blotch on each front wing.

The insect is with us the whole year. In the pupa state, in the ground, or under stones and other bodies, they pass a large part of the year, including the winter, while many perfect moths hibernate under the shelter of some concealing object. In the spring the mother moth devotes herself to egg-laying; which done, a day or two suffices at most, when she dies of sheer exhaustion. The appearance of the one-spotted Leucania in large armies, as a rule, can only occur after intervals of several years. The weather conditions which caused their appearance in New Jersey in 1880 in such amazing numbers were very remarkable. The winter had been so exceptionally mild that the moths came safely through hibernation and in large numbers. ' A rainless May, and unusually warm, brought in, in effect, a premature summer. Early potatoes failed; corn had to be replanted; rye was in ear in April; wheat began heading by the 12th of May, and such was the heat that the filling of the ears and the getting out of milk followed fast. Wheat-cutting began June 18, and at the end of the month the harvest generally was over,

nearly three weeks earlier than usual. And not only was *Leucania unipuncta* affected by the weather conditions of that remarkable year, but the insect tribe generally.

NOTES.

1. Since the foregoing was written I have seen "abstract" of a paper on *Leucania unipuncta*, read by Prof. C. V. Riley at the Boston meeting of the A. A. A. S., August, 1880. He says: "In the latitude of Saint Louis there are two, sometimes three, generations in a year, and, perhaps, even four; and farther south a succession of generations, scarcely interrupted during mild winters. Probably in New England there are two generations, the second one being 'usually unnoticed,' and existing through the autumn, winter, and early spring months.

"It is an established fact that the species hibernates both as larva and as moth, with strong circumstantial evidence that it also hibernates, particularly northward, as a chrysalis; but we have no evidence that it can hibernate in the egg.

"Excessive injury may result from natural local increase, or from moths flying in great numbers from other localities, and concentrating in particular fields. Dry seasons are favorable to the multiplication of the insect."

BIBLIOGRAPHY.

Acker- und Gartenbau-Zeitung.—"Die Heerraupe oder der 'Army Worm.'" July 1, 1880.

[A short account of the natural history of *Leucania unipuncta.*]

Allen, I. C.—"Further of the Army Worm." Prairie Farmer, vol. 8 (new series, 1861), p. 386.

Allen, ——."Ravages of the Army Worm." American Agriculturist, Aug., 1849, vol. 8, No. 8, p. 261.

[Army Worm very destructive in South Illinois and in Missouri.]

American Agriculturist.—"The Army Worm—its habits." July 18, 1880.

[Figures larva, pupa and adult, and considers the insect under the following headings: The insect described; how does it pass the winter; what it feeds upon; methods of destroying the worm.]

American Monthly Magazine and Critical Review. June, 1817, vol. 1, No. 2, p. 148–154.

[Includes notice of damage done by cut-worms, evidently *Leucania unipuncta*, in Massachusetts.]

B., H. P.—"The Army Worm." Valley Farmer, xiv [1862], p. 194.

[Speaks of the Army Worm parasites.]

Barnard, W. S.—"The Army Worm." Ithaca (N. Y.) Journal, July 8, 1880.

[A letter proving that from the abundance of parasites the worms need not be feared in 1881.]

Bartlett, Dr.—"More about the Army Worm." Prairie Farmer, vol. 8 (new series 1861), p. 3.

Bethune, C. J. S.—Annual Address Pres. Ent. Soc. Ont., 1875. Canadian Entomologist, viii (1876), p. 3.

Boston Daily Advertiser.—"The Army Worm in Essex County." June 28, 1880.

[Ravages and movements of larvæ of *Leucania unipuncta* in Essex County, Massachusetts; futile efforts to destroy the pests.]

Bradshaw, Jos.—"The Army Worm." Farmers' Register (Va.), 1835 (from Farmers' Reporter, Ohio).

[Account of the Army Worms in Ohio in 1825 and 1835.]

Bragshaw, Joseph.—"The Army Worm." Union Agriculturist, ii, p. 4, 1842.

[History, habits, and modes of prevention.]

Breed, Daniel.—"Recent Inventions for Insect Destruction." Department of Agriculture Report, 1876, p. 323–324.

[Describes a trap-lantern, and a boat-shaped drag for use in ditches filled with marching Army Worms.]

Colman's Rural World.—"The Army Worm and why so named." July 8, 1880.

[How to stay and destroy them; their development; precaution to be adopted; habits of the Army Worm; how to destroy the moth; the Army Worm described; its enemies.]

Comstock, J. H.—"The Army Worm." Cincinnati Grange Bulletin, July 15, 1880, and other agricultural periodicals of like date.

[A report made to the Commissioner of Agriculture on the Delaware invasion of 1880.]

Comstock, J. H.—"The Army Worm." N. Y. Herald, June 14, 1880.

[Report to the Commissioner of Agriculture on investigations in Kent County, Delaware, in June, 1880.]

Comstock, J. H.—"The Army Worm." Department of Agriculture Report, 1879, pp. 187–191.

[A condensed résumé of what had hitherto been published, with results of the investigations of the spring of 1880.]

Cook, A. J.—Canadian Entomologist, xiii (1881), 215.

[In report of meeting of Entomological Club, A. A. A. S., Professor Cook remarks on the appearance of *Leucania* in Michigan, in 1881—a dry year following a wet one. Discussed by Wm. Saunders and Cyrus Thomas.]

Cresson, E. T.—Canadian Entomologist, iv, 23, 1872.

[Describes *Mesochorus vitreus*, Walsh—a parasite on the Army Worm.]

Cultivator, The.—"Army worm." Aug., 1839, vol. 6, No. 6, p. 102.

[Ravages of *Leucania unipuncta*.]

Dodge, Robert.—"The Army Worm." Am. Rural Home, June 19, 1880.

[A rather lengthy compiled account.]

Dorman, S.—"Army Worm; new facts." Prairie Farmer, Feb. 1, 1862.

[Larvæ of *Leucania unipuncta* not always starting from vicinity of tame meadows; an army moved from southwest to northeast.]

Ferrill, Geo. W.—"More about the Army Worm." Prairie Farmer, vol. 8 (new series, 1861), p. 417.

[States that the eggs are laid in wheat in the fall or spring.]

Fitch, Asa.—"The Army Worm Moth." Cultivator and Country Gentleman, 1861 (written July 17).

[Describes moth and gives synonymy.]

Fitch, Asa.—"The Army Worm's Parasite." Boston Cultivator, Aug., 1861.

[Describes *Ichneumon leucaniæ*.]

Fitch, Asa.—"The Army Worm." Trans. N. Y. State Agric. Soc., 1860, vol. xx.

[Past history; habits; nomenclature; theory of appearances; description of moth; *Ichneumon leucaniæ*.]

Fitch, Asa.—"The Army Worm Moth." Boston Cultivator, Sept., 1861, pp. 278–279.

[Clears up synonymy and describes the moth.]

Flint, C. L.—Second Agricultural Report, Massachusetts (1854).

[In this report is an historical account of the weather from 1660 on, in which the Army Worm is several times mentioned.]

Flint, Chas. L.—Appendix to new edition of Harris's Insects Injurious to Vegetation (1862).

[Quotes descriptions from Fitch, and remedies from Kirkpatrick. Figures of larvæ, pupa and adult, and also two parasites.]

French, G. H.—"The Army Worm." Seventh Report of the State Entomologist, Illinois, 1877, p. 101–102.

French, G. H.—"*Leucania* (*Heliophila*) *unipuncta* Haw." Seventh Report of the State Entomologist, Illinois, 1877, p. 224–225.

[A brief review of the natural history, giving the number of broods in Illinois as two; in the southern part three.]

Glover, Townend.—Department of Agriculture Report, 1868, p. 79.

[A short account of the great number of Army Worms destroyed by the larva of *Calosoma calidum* (Fabr.)]

Glover, T.—"The Grass or Army Worm." Department of Agriculture Report, 1870, p. 83–84.

[A short compilation with poor original figures of larva and adult.]

Gould, John Stanton.—"Leucania unipuncta." Trans. N. Y. State Agric. Soc., 1872–'76, p. 47–50—in article entitled "On Forage Crops."

[A short article compiled from Harris, Kirkpatrick, Riley, and Fitch.]

Guenée, A.—"Leucania extranea." Lépidoptères—Noctuélites 1 (Tome 5, 1852), p. 77–78.

[Description of the moth with geographical distribution.]

Harper's Weekly.—"The Army Worm." July 3, 1880.

[A short editorial accompanied by an artistic illustration by Daniel Beard of all stages of the insect and its method of work.]

Haworth, A. H.—"Noctua unipuncta." Lepidoptera Britannica, ii (1810), p. 177.

[The original description of the moth, from one specimen found in the collection of Mr. Francillon.]

Heath, Dr. A. S.—"How to compensate for the Ravages of the Army Worm." American Rural Home, July 10, 1880; also Practical Farmer, July 31, 1880.
[Advises plowing and harrowing devastated fields, afterwards planting corn and potatoes.]

Herald, New York.—"The Army Worm." June 11, 1880.
[Reporter's description of the progress of *Leucania unipuncta* in New Jersey and the remedies tried.]

Hicks, Edw'd.—"The worm on Long Island in 1880." Cultivator and Country Gentleman, June 9, 1881.

Howard, L. O.—"The Army Worm." Moore's Rural Life (N. Y.), July, 1879.
[Figures larva, pupa and adult; gives experience in Southern Virginia in 1879, and gives descriptions and usual remedies.]

Howard, L. O.—N. Y. Semi-Weekly Tribune, Aug. 5, 1880.
[A short statement of an injurious brood of the Army Worm in Virginia the last week in July, proving that the first brood is not always the injurious one.]

Howard, L. O.—"The Army Worm." Huntsville Democrat (Ala.), May 10, 1882.
[A brief résumé of the life history of Leucania with notes on the 1882 appearance at Huntsville.]

Howard, L. O.—"The Army Worm." Chattanooga, Tenn., Times, May 12, 1882.
[Corrects local opinions in reference to the Army Worm.]

Howard, L. O.—"Strange Habit of Metapodius femoratus, Fabr." American Naturalist, July, 1882. (Published in June.)
[Describes habit of Metapodius in hanging up the empty skins of Leucania, after sucking their juices, in crotches of May weed (*Maruta cotula*).]

Howard, Sanford.—Boston Cultivator, xxiii, 276 (1861).
[A notice of the parasite afterwards described by Fitch as *Ichneumon leucaniæ*.]

Indiana Farmer.—"The Army Worm." September 18, 1880.
[A compiled editorial article.]

Indiana Farmer.—"The Army Worm abroad." July 3, 1881.
[An extended account of the appearance of the worm in Indiana and Iowa in 1881, with a short review of its natural history.]

Indiana Farmer.—"The Army Worm." Aug. 6, 1881.
[An account of the ravages of the worms in Eastern Indiana in 1828.]

June Isle.—"Sir Thomas *vs.* Sir Walsh." Prairie Farmer, vol. 8 (new series, 1861), pp. 373, 408.
[A humorous criticism of the Walsh-Thomas Army Worm controversy.]

King, J. C.—"Army Worm: Hungarian Grass." Prairie Farmer, after 27 May, 1861.
[Occurrence of *Leucania unipuncta* "by the millions" in Warren Co., Mo.; their ravages.]

Kirkpatrick, Jno.—"Notes on a few of the insects of Northern Ohio, injurious to the farmer or horticulturist." Tenth Annual Report Board of Agriculture of Ohio, 1855, p. 246.
[Gives on this page a short description, without name, of *Leucania unipuncta*, in all its stages except egg, and an account of its work on the Cuyahoga Flats in 1855.]

Kirkpatrick, Jno.—"The Army Worm (*Leucania extranea*)." Fifteenth Annual Report State Board of Agriculture of Ohio, 1860, pp. 350-358.
[Extended descriptions of larva, pupa and adult; advises ditching, rolling, and burning; also swine and poultry; mentions five parasites and describes *Exorista leucaniæ* and *Ex. osten-sackenii*.]

Klippart, J. H.—"The Army Worm Question." Field Notes, 1861, p.—(November.)
[A controversial answer to one of Walsh's Prairie Farmer articles, in which the writer urges that the worms are viviparous.]

Klippart, J. H.—"The Army Worm Question again." Field Notes, December 7, 1861.
[Contradicts Walsh's "hibernation of the egg" theory, and also denies the existence of secondary parasites; also ridicules other minor statements of Walsh's.]

Klippart, J. H.—"Army Worm; Mr. Klippart's Rejoinder." Field Notes, December, 1861.
[Controversial answer to Walsh's article of December 14.]

Klippart J. H.—"The Locusts which ate up King Pharaoh." Ohio Farmer, January 3, 1863.

[In the course of this article he replies to Walsh's challenge to produce a larva which could bear young (referring to Klippart's theory that the Army Worms were viviparous) by citing Westwood on Stylopidæ.]

Lintner, J. A.—"The Army Worm." Cultivator and Country Gentleman, July 3, 1879.

[Answer to letter from "A. H. L.," Portsmouth, Va., giving the known history of the worm.]

Lintner, J. A.—"The Insects of the Clover Plant." Annual Rept. N. Y. State Agr. Soc., 1880.

[Mentions *Leucania unipuncta* among the insects injurious to the clover plant.]

Lintner, J. A.—"New Insects—not the Northern Army Worm." Cultivator and Country Gentleman, June 9, 1881.

[Describes work of *Nephelodes violans* Guen., which had been mistaken in New York for the true Army Worm.]

"M."—"The Army Worm." American Agriculturist, February, 1847, vol. 6, No. 2, p. 50.

[Review. American Agricuturist, July, 1847, vol. 6, No. 7, p. 209.]

McBryde, Jno. M.—"The Army Worm." Experimental work of the Agricultural Department, University of Tennessee, 1879–'80, pp. 76–84.

[A good account of the visitation from the Army Worm, in East Tennessee, in May and June, 1880.]

McBryde, Jno. M.—"The Army Worm." Experimental work of the Agricultural Department, University of Tennessee, 1881, pp. 200–203.

[An account of a second invasion the ensuing year (1881) of the same localities ravaged in 1880.]

Mirror and Farmer.—"The Army Worm." July 3. 1880.

[A lengthy article, quoting from different New England papers to show the progress of the pest.]

Muse, Joseph E.—"Entomology." American Farmer, July 16, 1819, vol. 1, no. 16, col. 3, pp. 124–125.

[Describes transformations of the "grub worm" (*Elater?*), which destroys corn plants in the field, of the fruit curculio (*Conotrachelus*), and of army worms (*Leucania*); means against these insects.]

New England Farmer.—"The Army Worm." July 2. 1830, p. 397. (Quotes from Illinois Gazette.)

[A short account of the appearance of the worms in Illinois in 1829.]

New England Farmer.—Vol. liv (new series, vol. xxx): Nos. 31 and 34, Ravages of *Leucania unipuncta* in R. I. and Mass.; No. 33, in Long Island; No. 35, in N. H. (1880).

New Jersey Farmer.—"The Army Worm." III (1857), p. 10.

[Describes ravages in Maryland in 1857, and describes Microgaster and Tachina parasites.]

New Jersey Farmer.—"The Army Worm." VI, 366 (1861) (from the Maine Farmer).

[A most astonishing jumble. Confounds *Leucania* with *Aletia xylina*.]

Ohio Farmer.—July 1, 1876.

[An editorial account of the discovery of the eggs of the Army Worm Moth by Professor Riley.]

"P., X."—"The Army Worm." Cultivator and Country Gentleman, June 9, 1881.

[A compiled account, reproducing Riley's figures of larva, pupa and moth.]

Pacific Rural Press.—"The Army Worm." July 16, 1881.

[An account of an insect damaging vineyards, fodder fields, and gardens. The old eastern remedies for Army Worm are given.]

Packard, A. S., jr.—"The Army Worm." Sixth Report Secretary Maine Board of Agriculture, 1861, pp. 130–142.

[An extended account, quoting freely from Walsh and adopting his views; describing larva, pupa, adult and all of Walsh's parasites.]

Packard, A. S., jr.—Guide to the Study of Insects, p. 305, 1869.

[Figures on Plate 8, figs. 2 and 2 *a*, larva and adult. A brief review of natural history and remedies.]

Packard, A. S., jr.—"The Northern Army Worm." Ninth Annual Rept. U. S. Geological and Geographical Survey of the Territories, 1875, pp. 699–709.

[An excellent compilation of previous articles.]

Parsons. Col.—"Grasshoppers and the Palmer Worm." Papers; * * * Massachusetts Society for Promoting Agriculture, 1807, pp. 32, 33.

[Account of an invasion of locusts in 1792 and 1793, and of palmer worms [*Leucania?*] in 1801 [?] and 1807 [?], in eastern Massachusetts [?]. Means against the latter insects.]

Payne, A. H.—"Singular Facts." Cultivator, v, 192 (1838).

[In 1835 the Army Worm stripped leaves of wheat and averted rust.]

Periam, Jonathan.—"The Army Worm." American Encyclopedia of Agriculture, Chicago, 1881.

[Figures larva and adult, and gives a short account from Riley.]

Pleasant, J. A. W.—"Grain Worm, Chinck Bug, Dutton Corn." Cultivator * * * Buel, May, 1836, vol. 3, ed. 2, pp. 41,42.

[Attacks of caterpillars [*Leucania?*] upon wheat, in 1789 and 1807; habits and ravages of *Blissus leucopterus*. The "grain worm" or "wheat worm" appears to be *Cecidomyia tritici*.]

Prairie Farmer.—"The Army Worm." July 8, 1865.

[Figures larva, pupa and adult, and gives the old remedies.]

Prairie Farmer.—"The Army Worm." April 26, 1879.

[An editorial account taken chiefly from Thomas and Riley.]

Porter, J. R.,—"The Army Worm." Cultivator * * * Buel, September, 1837, vol. 4, No. 7, pp. 116,117.

[Ravages of *Leucania unipuncta*.]

Powers, Rev. Grant.—"Historical Sketches of the Coös County." Haverhill, N. H., 1841, pp. 105–108.

[Gives an account of the 1770 outbreak of the Army Worm in New England, which has been since so extensively quoted by Fitch and others.]

Rathvon, S. S.—Notes on the Army Worm. Lancaster Farmer, July, 1880.

[Experiences of different persons in the matter of remedies.]

Rathvon, S. S.—"A Supplement to the Army Worm." Lancaster Farmer, Aug., 1880, p. 114.

[Variations: two broods; hibernation in moth state.]

Riley, C. V.—"Army Worm and Canker Worm Wisdom." Prairie Farmer, vol. xviii (new series, 1866). p. 28.

[Corrects mistake made at Western N. Y. Fruit Growers' Association, as to identity of Army Worm with some tree caterpillar.]

Riley, C. V.—Second Annual Report of State Entomologist of Missouri, 1870, pp. 37–56.

[Other insects known as Army Worms; past history; sudden appearance and disappearance; natural history; parasites; habits and suggestions for its destruction, &c.]

Riley, C. V.—"What are Army Worms?" N. Y. Semi-Weekly Tribune, February 6, 1875.

[Gives difference between *Laphygma frugiperda* and *Leucania unipuncta*.]

Riley, C. V.—"The Army Worm: An important fact yet to ascertain in its natural history." N. Y. Semi-Weekly Tribune, November 16, 1875.

[Figures larva, pupa, and adult; also four parasites; gives probable locality and appearance of eggs.]

Riley, C. V.—Eighth Annual Report of State Entomologist of Missouri, pp. 22–56 (1876).

[Term Army Worm applied to various insects; past history; sexual differences; natural history; description of egg; where the eggs are laid; when the eggs are laid; in what state does the insect hibernate; habits of worm; time of appearance; number of broods. Fall Army Worm; food plants; sudden appearance and disappearance; natural enemies; remedies; summary.]

Riley, C. V.—"The Army Worm: Additional Notes on the Mode, Place, and Time of Oviposition." Eighth Annual Report of State Entomologist of Missouri (1876), pp. 182–185.

[First announcement of the discovery of the eggs.]

Riley, C. V.—"Biological Notes on the Army Worm." Proceedings of American Association for the Advancement of Science, xxv, pp. 279–283 (1876).

[Figures larva, pupa, and adult; describes eggs and all other stages; hibernation of moths; two broods at Saint Louis.]

Riley, C. V.—"The Army Worm: Its Natural History Complete." Scientific American, xxxv, p. 372, December 9, 1876.

[The paper read before the A. A. A. S., 1876, popularized and condensed. Figures and describes all stages of *Leucania unipuncta*.]

Riley, C. V.—"Oviposition of *Leucania unipuncta*." American Naturalist, vol. x, (1876), pp. 508–509.

Riley, C. V.—"The Army Worm: Further Notes and Experiments thereon." Ninth Annual Report of Entomologist of Missouri, 1877, pp. 47–50.

[Number of annual generations; summary of natural history.]

Riley, C. V.—"Complete Life History of the Army Worm (*Leucania unipuncta*) and its parasites." Massachusetts Agricultural Report, 1878.

[Walker Prize Essay. Largely taken from the 8th and 9th Missouri Entomological Reports.]

Riley, C. V.—"The Northern Army Worm." American Entomologist, iii, 170 (1880.)

[Characters; natural history; remedies; summary from 9th Missouri Rept.; figures of eggs, ♀ genitalia, larva, pupa, adult.]

Riley, C. V.—"Further Notes and Observations on the Army Worm." American Entomologist, iii, 184, and continued on p. 214 (1880).

[Number of annual generations; how the insect hibernates, the destructive generation probably not the first of the season; how far burning over is a preventive; connection of wet and dry seasons with Army Worm increase.]

Riley, C. V.—"The Genuine Army Worm in the West." American Naturalist, September, 1881, p. 750.

[A short notice of the appearance of the Army Worm in Illinois and Indiana.]

Riley, C. V.—"The Army Worm *vs.* The Clover Hay Worm." Rural New Yorker, June 10, 1882.

[An account of the appearance of the worms in Tennessee and Alabama, and of the mistaken views of planters concerning the originating of the worms in old clover lands, arising from a confusion of the Army Worm with the Clover Hay Worm.]

Rural New Yorker.—"The Army Worm." June 12, 1880.

[*Leucania unipuncta* appears on Long Island, N. Y., in vast numbers, and is very destructive to crops.]

Rural World.—"The Army Worm." Aug. 4, 1881.

[An account of the damage done in Illinois in late July by the worms, principally to oats.]

Saunders, Wm.—"Annual Address of the President of the Entomological Society of Ontario." Canadian Entomologist, xiii, 197 (1881).

[On pp. 198 and 199, speaks of the Army Worm as double brooded, and probably hibernating in the larva state; and predicts comparative exemption in 1882 in Ontario.]

Scientific American.—"The Army Worm." June 16, 1880.

[A short account of the ravages on Long Island.]

Scientific American.—"The Army Worm." June 16, 1880.

[A lengthy illustrated account compiled from Riley.]

Scudder, S. H.—Canadian Entomologist, vii (1875), pp. 178–179.

[A report of a meeting of the Entomological Club, A. A. A. S., in which Mr. Scudder remarked on the abundance of the Army Worm in Massachusetts.]

Scudder, S. H.—"Recent Progress of Entomology in N. A. First annual address of the President of the Cambridge Entomological Club." Psyche, ii (1878), p. 97.

[On p. 113, in reviewing Thomas's Illinois Report, especially mentions his conclusions that Leucania is normally a cut-worm, and calls attention to the fact that it has no scientific basis.]

Shurtleff, C. A.—"The Army Worm." Proceedings Essex Institute, iii, 193-200 (July 2, 1862).

[Quotes extensively from Fitch, Kirkpatrick, and Walsh; describes Microgaster cocoons as Leucania eggs.]

Snow, F. H.—"Not the Army Worm." Lawrence (Kansas) Journal, July 28, 1880.

[An account of the *Eurycreon rantalis* of Guenée, mistaken in Kansas for the Army Worm.]

Springfield Republican.—"Agricultural Department's View of the Army Worm." June 16, 1880.

[Notes on authority of J. H. Comstock in regard to *Leucania unipuncta*, and modes of destroying it.]

Stainton, H. T.—"Leucania extranea." Entomologist's Annual, 1860, pp. 129, 130.

[Notes of the capture of this moth at the Isle of Wight and at Lewes.]

Stephens, J. F.—"Noctua impuncta." Systematic Catalogue of British Insects, 1829, ii, p. 101, No. 6350.

Stephens, J. F.—"Noctua impuncta." Illustrations of British Entomology, Haustellata, iii (1829), p. 80.

[Describes the specimen found in Haworth's collection, by mistake, as *impuncta* instead of *unipuncta*.]

Stephens, J. F.—"Noctua unipuncta." List of the Lepidoptera in the British Museum. 1850, p. 289.

Sun, N. Y.—Sunday, June 20, 1880.

[A lengthy article, principally an interview with Professor Riley, containing a good summary of present knowledge of the Army Worm.]

Templin, L. J.—"The Army Worm." Ohio Farmer, Sept. 23, 1876.

Thomas, C.—"Further from the Army Worm." Prairie Farmer, vol. 8 (new series, 1861), p. 100.

[Facts concerning the worms in Jackson Co., Ill., 1861.]

Thomas, C.—"The Army Worm." Illinois Farmer, September, 1861.

[Describes larva, pupa, and adult; and advises plowing under the grass while the worms are yet small.]

Thomas, C.—"The Army Worm Question." Prairie Farmer, vol. 8 (new series, 1861), p. 293.

[Controversial answer to Walsh's theory of egg hibernation: believes his "first notion as to a double brood" incorrect.]

Thomas, C.—"Army Worm Question Continued." Prairie Farmer, vol. 8 (new series, 1861), pp. 306-307 (3½ columns).

[Brings up many arguments against egg hibernation, and in favor of pupal hibernation.]

Thomas, Cyrus.—"The Army Worm." Prairie Farmer, vii (new series, 1861), p. 363.

Thomas, Cyrus.—"The Army Worm." Prairie Farmer, vol. 7 (new series, 1861), pp. 393,400.

[Figures larva and pupa, with descriptions, advises as remedy to plow under the infested crop and sow with corn, turnips, or buckwheat.]

Thomas, Cyrus.—"Army Worm." Sixth Report of the State Entomologist of Illinois, 1876, pp. 56-59.

[Calls the species normally a cut-worm, and states that the marching habit is abnormal; brings up observations to prove this.]

Thomas, Cyrus.—"The Army Worm." Tenth Report of the State Entomologist of Illinois (1880), pp. 5-43.

[Past history; Natural history, and description; Eggs; Larva; Pupa; Moth; Terms of life; Dates of captures of the moth; Notices of the larvæ; Number of broods and hibernation; Proper home of the species and character of seasons favorable for its development; Remedial agencies.]

Thomas, Cyrus.—Canadian Entomologist, xiii, 181 (1881).

[Remarks before the Entomological Club of the A. A. A. S., as to the duration of life of the Army Worm. Conclusions disputed by Prof. Riley and Mr. Mann.]

Thomas, Cyrus.—"Insects injuring field crops, and forecasts in reference thereto for next year." Farmers' Review, Nov. 24, 1881.

[Predicts the appearance of the Army Worm in a moist season following a dry one.]

Wait, Wm. S.—"The Army Worm." Missouri Reporter, 1842.

[History, habits, and modes of prevention.]

Reimpr.—Union Agriculturist, ii, p. 53, 1842.

Walker, F.—"Leucania extranea." List of the Lepidoptera in the collection of the British Museum, part 9, species 32, under Leucania.

Walsh, B. D.—"Army Worm and its enemies." Prairie Farmer, vol. 8 (new series, 1861), p. 4. (One column and a half.)

[A popular account of some of the parasites of the Army Worm.]

Walsh, B. D.—"The Army Worm." Prairie Farmer, vol. 8 (new series, 1861), p. 257–258.

[Holds that eggs hibernate, and that spring burning is an effectual remedy; describes *Hockeria perpulchra*, and gives notes on other parasites.]

Walsh, B. D.—"The Army Worm Question." Prairie Farmer, vol. 8 (new series, 1861), pp. 370, 377. (6 columns).

[Reply of Benj. D. Walsh to Cyrus Thomas on the question of hibernation.]

Walsh, B. D.—Valley Farmer, xiv (1862), p. 161.

[Corrects mistakes of E. S. Washington and remarks on the economy of the Army Worm parasites.]

Walsh, B. D.—"From Benjamin D. Walsh." Illinois Farmer, October, 1861.

[Corrects Thomas for stating that he (Walsh) believed in the hibernation of the pupa of Leucania.]

Walsh, B. D.—"The Army Worm Question—Mr. Walsh's Reply." Field Notes, Dec. 14, 1861.

[Controversial answer to Klippart's article of Nov. 30.]

Walsh, B. D.—"The Army Worm and its insect foes. The remedy." Transactions Illinois State Agricultural Society, iv (1861), pp. 349–372.

[This is part of the essay entitled "Insects injurious to Vegetation in Illinois." Figures larva, pupa, adult, and parasites. Describes *Senometopia militaris*, *Pezomachus minimus*, *Microgaster militaris*, *Chalcis albifrons*, and *Glyphe viridascens*. Advises, as remedy, burning tame grass in dead of year.]

Walsh, B. D.—"The Army Worm." Premium essay on insects injurious to vegetation in Illinois. Transactions Ill. State Agr. Soc., v. 1861–'64, p. 470; P. S. 501.

[Figures larva, pupa, adult, *Senometopia militaris*, *Pezomachus minimus*, *Chalcis albifrons*, *Mesochorus vitreus*, *Microgaster militaris*, and *Glyphe viridascens*. Principally controversial, upholding egg hibernation.]

Walsh, B. D.—"Popular names for insects." Practical Entomologist, i, 97 (1866).

[The text for this article is the announcement in the Sacramento Bee of the appearance of the "fly" of the Army Worm.]

Walsh, B. D.—The three so-called Army Worms." Practical Entomologist, ii, p. 111 (1867).

Walsh, B. D.—"The Army Worm and its insect foes." Prairie Farmer, vol. 8 (new series, 1861), pp. 322–323, 337–339, 354–355.

[Figures larva, pupa, and adult; also *Exorista leucaniæ*, *Pezomachus*, *Hockeria*, *Microgaster*, *Glyphe*; gives facts in favor of egg hibernation; describes very carefully moth and larva, and gives habits, &c.]

Walsh and Riley.—"The true Army Worm." American Entomologist, i, pp. 214, 217 (1869).

[Figures larva, pupa, adult, and *Exorista militaris*, Walsh. Habits; remedies; parasites; single brooded; may sometimes be a friend by devouring chess, or by stripping off blades affected with rust.]

Washington, E. S.—"The Army Worm." Valley Farmer, xiv (1862), p. 161.

[States that the worm is viviparous, having mistaken parasitic larvæ for young Army Worms.]

Webster, F. M.—"Observations on the Army Worm." Our Home and Science Gossip, January, 1882 (continued in the February, 1882, number).

[Observations in Illinois, during 1881, on character of infested fields, number of broods and parasites.]

Webster, Noah.—Pestilential Diseases, i, 259.

[Quoted by Fitch concerning the worms in 1770.]

Wiley, Benj. F.—"The Army Worm." Prairie Farmer, vol. 8 (new series, 1861), p. 37.

[Character of infested fields; length of life; clover eaten.]

Wislizenus, Dr. A.—"The Army Worm." Journal and Proceedings Saint Louis Academy Sciences, ii, pp. 159, 160.

[Gives a fair life-history of the insect, but wrongly identifies it as the European *Bombyx graminis.*]

CHAPTER VII.

CANKER WORMS.

The term Canker Worm has formed the heading of so many articles in the various agricultural and horticultural journals and magazines, and State and other reports, during the last twenty or twenty-five years, and the natural history of these insects has been in many particulars so fully given in standard works, that one almost wonders where there can be a reading farmer who does not know how properly to cope with them; yet information is constantly sought on the subject, and as it is only of late years that some essential facts have been fully understood, we propose to bring together here whatever is necessary to a complete understanding of these pests.

To obviate misunderstandings in the outset it should be stated that two quite distinct insects have been recognized as properly bearing the name of "Canker Worm," while this name is frequently applied improperly to numerous other insects.

The true Canker Worms of this country are native species, and are confined to North America. One of them, however, *Anisopteryx pometaria*, is closely related to an European species, *Anisopteryx æscularia*, and resembles the latter so closely, in its adult state, that the two may easily be confounded by the inexperienced observer; more easily, indeed, than our two native species with each other. The distinctive characters of the American and the European *Anisopteryx*, even in the adult stage, are sufficient, however, for ready discrimination by the trained observer, and those in the immature stages are still more evident, as will be shown hereafter.

One of the characters which all species of Canker Worm moths have in common is the possession of ample wings by the male and the lack of wings in the female. It is upon this peculiarity of the female that most of the propositions of remedies are based. The females generally being able to move about, or make their way into the trees to deposit their eggs, only by crawling, any efficient means of preventing them from ascending upon the trunk to the branches of the trees will largely aid in protecting these from damage by the worms, and, if accompanied by such measures as will prevent the newly hatched worms from ascending, will prove a perfect preventive.

CLASSIFICATION.

Canker Worms are distinguished from most other caterpillars which attack the apple-tree, by having a less number of fleshy supporting legs

under the hinder part of the body. The normal number of such so-called prolegs in caterpillars is ten, while the Canker Worms have but either four or six. The lack of the foremost prolegs obliges them to span or loop in walking, from which habit the characteristic names of Span Worms, Measuring Worms, and *Geometridæ*, have been given to them as well as to the other members of the family to which they belong.

The generic name *Geometra*, from which is derived the family name *Geometridæ* (meaning "of the *Geometra* family") signifies a geometer or measurer of the earth.

The name of *Geometridæ* is by many authors at the present day considered to apply only to a restricted group in the larger family of the *Phalænidæ*, while by other authors the same name is applied to the larger family.

In either case this larger family is differently sub-divided by different authors; thus, Harris places the Canker Worms in the family *Hyberniadæ*, Guenée in the family *Hybernidæ*, and Packard[48] in the subfamily *Boarminæ*.

This family, *Geometridæ* or *Phalænidæ*, forms one of the main sub-divisions of the order *Lepidoptera*.

Without describing in detail the structural characters of the order or the family, which would be inappropriate in this special work (although, of course, the Canker Worms must partake of these characters), we will mention here certain particulars wherein the Canker Worms are peculiar or specially characterized.

Dr. Packard says that "although it is stated[49] that the *Phalænidæ* have no ocelli," he has "found that they generally occur in our species; though, compared with those of the *Noctuidæ*, they are small, and easily overlooked. They are situated very near the eyes, usually on the suture between the epicranium and occiput. * * * They are present or absent in different species of the same genus. * * * It is a question whether they are ever of use to the insect, as, in most cases, they appear as if partially aborted, and their presence and absence in different species of the same genus show that they are not very essential to the life of the insect."

TWO DISTINCT INSECTS CONCERNED.

There are two distinct species working on our elm and apple-trees as well as on some few other shade and fruit trees. The two have very generally been confounded, and it is very important that their differences should be understood and kept in mind.

In our Seventh Annual Report on the Insects of Missouri, we illustrated and explained the differences in habit and structure between the two, and gave a detailed comparative description of these two insects in their different stages, the descriptions of the moths being but slightly

[48] Monograph of the Geometrid Moths, p. 397.
[49] Guenée, Uranides et Phalénites, v. 1; Généralités, p. 21.

altered from those originally drawn up by Mr. Mann, to whom we were under obligations for specimens of *pometaria* in all stages, and for the use of his notes.

Further investigations, during 1875, enabled us to complete still more fully the comparisons previously instituted, and showed that the structural differences were greater than we had at first supposed, in consequence of which we were led to separate the insects generically in a paper, read October 14, 1875, before the Academy of Science of Saint Louis, erecting the new genus, *Paleacrita*, for *vernata*, and retaining *pometaria* in the genus *Anisopteryx*, to which it alone of the two species can be referred. The following table of differences is taken from a reprint of the above-mentioned paper, which appeared in our Eighth Missouri Report, with only such changes as are necessitated by the proper references to the figures and by subsequent observations.

Paleacrita vernata.	*Anisopteryx pometaria.*
EGG.	
Elliptic-ovoid, the shell of delicate texture and quite yielding; generally appearing shagreened or irregularly impressed; nacreous, and laid in irregular masses in secreted places. (Pl. III, Fig. 1, *b.*)	Squarely docked at top, with a central puncture and a brown circle near the border; of firm texture, and laid side by side in regular rows and compact batches, and generally exposed. (Pl. III, Fig. 5, *a, b, c.*)
No prolegs on joint 8. (Pl. III, Fig. 1, *a.*)	With a pair of short but distinct prolegs on joint 8. (Pl. III, Fig. 5, *f.*)
Head distinctly mottled and spotted, the top pale, and two pale transverse lines in front.	Head very indistinctly spotted, and dark on top.
Body with eight superior, narrow, pale, longitudinal lines barely discernible, the two lowermost much farther apart than the others.	Only six superior, broad, and very distinct pale lines, those each side equidistant.
Dorsum pale, with median black spots; subdorsal region dark; stigmatal region quite pale.	Dorsum dark, without ornament; subdorsal region pale, stigmatal region dark.
Piliferous spots quite visible and large on joint 11, where the pale lines generally enlarge into white spots immediately in front of them.	Piliferous spots subobsolete.
When newly hatched *dark* olive-green or brown, with black shiny head and cervical shield.	When newly hatched *pale* olive-green, with very pale head and cervical shield.
CHRYSALIS.	
Formed in a simple earthen cell, the earth compressed, and lined with very few silken threads so as to form a fragile cocoon, which easily breaks to pieces.	Formed in a perfect cocoon of fine, densely spun silk of a buff color, interwoven on the outside with particles of earth; never breaking open except by force or purpose.
MALE—Sparsely and shallowly pitted. Pale grayish-brown, with a greenish tint on the wing-sheaths, which extend to the	MALE—Punctation very faint, more or less obsolete. Darker brown than *vernata*; the wing sheaths, as in *vernata*, reaching

Paleacrita vernata.	*Anisopteryx pometaria.*
posterior edge of the 5th abdominal joint; abdomen with the spine at tip generally simple, and only occasionally slightly bifurcate.	to the 6th abdominal joint; the anus more blunt and with the spine more dorsal, decurved, and always bifurcate, the prongs spreading and often long and fine. (Pl. III, Fig. 8, *a*.)
FEMALE—With wing-sheaths, but compared with those of the male, thinner and extending only to the posterior edge of the 4th abdominal joint: much more robust and more arched dorsally, with the mesothoracic joint shorter, and much reduced in size. Pitted like the male. (Pl. III, Fig. 4.)	FEMALE—Differs from the male in the same way as *vernata*, but is relatively stouter and more arched dorsally: a broad, dusky, dorsal stripe often visible toward the time of issuing—all the more remarkable that there is no such stripe on the imago, whereas in *vernata*, where the imago has such a stripe, it is not indicated in the chrysalis. (Pl. III, Fig. 8, *b*.)

IMAGO.

Paleacrita vernata.	*Anisopteryx pometaria.*
Abdomen with the first seven joints bearing each two transverse dorsal rows of stiff, reddish spines, pointing posteriorily.	*Abdomen* without spines.
MALE—*Palpi* very short, but distinctly 2-jointed.	MALE—*Palpi* rudimentary with joints indistinguishable.
Antennæ with not quite 40 joints, the longest more than twice as long as wide, each with *two pairs* of hair fascicles, springing from very slight, lateral elevations, the longest hair about thrice the diameter of joint. Looking from above, with ordinary lens-power, these hairs give the appearance of fine, ciliate pectinations. (Pl. III, Fig. 2, *c*.)	*Antennæ* with over 50 joints, the longest not twice as long as wide, each with *one pair* of fascicles of slightly curled hairs, the longest about thrice as long as the diameter of the joint, and all springing from a prominent, dark hump which occupies the basal half of the joint beneath, and gives a somewhat serrate appearance from the side. The same appearance of ciliate pectinations looking from above. (Pl. III, Fig. 6, *c*, *d*.)
Wings delicate, silky, semi-transparent, transversely striate, the scales short and very loosely attached.	*Wings* less transparent, more glossy, not striate, the scales on an average longer and more firmly attached.
Front-wings with costal and sub-costal veins well united, with the discal cross-vein partially open, and but *two* short costal branches, the superior veins straight.[50] (Pl. III, Fig. 2, *a*.)	*Front-wings* with costal and sub-costal less closely united, with the discal cross-vein well closed, and with *three* costal branches. All the veins 7–11 are more distinctly separated and the superiors more curved, veins 9 and 10 forming an open areolet near the disc: the apex more produced. (Pl. III, Fig. 6, *a*.)
Upper surface brownish-gray.	Upper surface also brownish-gray, but somewhat darker, with a purplish reflection.
Crossed by three jagged, dark lines, sometimes obsolete except on the submedian and median veins, and on the costa	Crossed by two less jagged, whitish bands, the outermost suddenly bending inward near costa, at about three-fourths the

[50] A microscopic examination shows the venation in *vernata* to be on the same plan as that in *pometaria*. The difference is that in *vernata* the costal vein is feeble and generally obsolete at its termination, and all the veins 7–12 are more closely united with the costal than in *pometaria*.

where they are always distinct and divide the wing into four subequal parts. No white costal spot. (Pl. III, Fig. 3, *a.*)	distance from base to apex, where it forms a pale, quadrate spot, relieved by a darker shading of the wing around it: the bands sometimes so obsolete as to leave only this pale spot; but more often relieved on the sides toward each other by a dark shade, most persistent on the veins. (Pl. III, Fig. 7, *a.*)
A pale, jagged, subterminal band, corresponding in some degree to the outermost band in *pometaria*, but running out to apex, where it is always sharply relieved posteriorly by a dark mark, and often the whole length by dusky shadings.	No such band.
Hind-wings with the costal vein bifurcating at, or but little beyond, the discal, and with the independent or vein 5 faint. (Pl. III, Fig. 2, *b.*)	*Hind-wings* with the costal vein bifurcating considerably beyond the discal, which is strongly elbowed; vein 5 quite strong. (Pl. III, Fig. 6, *b.*)
Color pale-ash or very light gray, with a dusky discal dot.	Grayish-brown, with a faint blackish discal dot.
No white band, and rarely any marginal dots.	In most specimens a curved white band runs across the wing, and the veins inside this band and on hind border are generally dotted.
Under surface with a more or less distinct dusky spot on each wing, the front wing having in addition a dusky line along median vein and spot on costa toward apex. No pale bands.	*Under surface* with a dusky discal spot on each wing, and with the outer pale band on upper surface of front-wings as well as that of the hind-wings showing distinctly, the former relieved by a dusky spot inside at costa.
FEMALE—*Antennæ* generally with but few more than 30 joints, the longest about thrice as long as wide, faintly constricted in middle, and pubescent. (Pl. III, Fig. 3, *c.*)	FEMALE—*Antennæ* with over 50 joints, the longest hardly longer than broad; uniform in diameter; without pubescence. (Pl. III, Fig. 7, *c.*)
Body and legs pubescent, clothed with whitish and brown, or black, dentate scales or hairs; general coloration not uniform. Crest of prothorax and mesothorax black. A black stripe along the middle of the back of the abdomen, often interrupted on the second to seventh joints, with a whitish patch each side of its front end. (Pl. III, Fig. 3, *b, d.*)	*Body and legs* smooth, clothed with glistening brown and white truncate scales intermixed, giving it an appearance of uniform, shiny, dark ash-gray: somewhat paler beneath. (Pl. III, Fig. 7, *b. d.*)
Abdomen tapering rather acutely behind, and with an exsertile, two-jointed, conspicuous ovipositor. (Pl. —, Fig. 9, *c.*)	*Abdomen* tapering rather bluntly behind, without exsertile ovipositor.
Two rows of spines on back of the first seven joints more prominent than in the male, and often giving the dorsum a reddish aspect. (Pl. III, Fig. 3, *d.*)	No spines on abdomen.
Of a rather smaller size than *pometaria*, the wings of the male expanding from 0.86-1.30 inches, and the female measuring 0.20-0.35 inch in length.	The wings of the male expand from 1.05-1.35 inches; and the female measures 0.25-0.40 inch.

We thus have two distinct species of Canker Worms, differing not only in habit, but differing so much structurally in all states that they may at once be distinguished from each other. In contrast with the soft, delicate, ovoid eggs secreted in irregular masses, the 10-legged larva, and the spined and hairy moths of *vernata*, we have the tough, flower-pot-shaped eggs, laid in exposed, regular masses, the 12-legged larva, and the spineless, smooth moths of *pometaria;* and the specific structural differences are still apparent when we come to examine the genital armature of the males. It is really remarkable that these differences remained so long unnoticed, especially in those parts of the country where *pometaria* abounds.

The distinctions between these two insects, so long confounded, forcibly illustrate the practical importance of minute discriminations in economic entomology.

Pometaria agrees with the European species of *Anisopteryx* in the principal pterogostic characters, obsolete tongue, and rudimentary palpi; and is, indeed, the analogue of the well-known *æscularia.*

Yet, in the antennal characters of the male, and especially in the basal hump on each joint, it [*pometaria*] agrees more nearly with the typical species of the genus *Hybernia* as characterized by Guenée [than with *æscularia*]. So far as we now know, also, it differs from the European species of *Anisopteryx* in the more distinct areolet in the front wing.

The genus *Paleacrita* approaches much nearer *Hybernia*, from which it is, however, readily distinguished by the double pair of hair fascicles to each ♂ antennal joint; the pubescent hairs that cover the female; the two-jointed, horny, exsertile ovipositor; but, more especially, by the dorsal abdominal spines in both sexes—all characters unmentioned in existing diagnoses of the genus.

NOMENCLATURE.

From the time when William Dandridge Peck published (in 1795) his essay on the Canker Worm, which received a prize from the Massachusetts Society for Promoting Agriculture, up to the year 1873, all writers on the subject spoke of The Canker Worm, under the impression that all Canker Worms were of one species. Until that time no other distinctive name appears to have been borne by them. In that year Mr. Peck described one of the species in such a way that it could be recognized, and gave to it the name of *Phalæna vernata.* No further progress in naming the insects was made until 1841, when Dr. Thaddeus William Harris presented A Report on the Insects of Massachusetts, Injurious to Vegetation, to the Commissioners on the Zoological and Botanical Survey of Massachusetts, which report was published in the same year. In this, on page 332, speaking of the *Geometræ*, he says:

Those kinds, whereof the females are wingless, or have only very short, scale-like wings, and naked antennæ, while the males have large, entire wings, and feathered or downy antennæ, seem to form a distinct group, which may be named Hybernians

(HYBERNIADÆ), from the principal genus [*Hybernia*] included therein. The caterpillars have only ten legs, six before and four behind; and they undergo their transformations in the ground. The insects called canker-worms, in this country, are of this kind. The moths, from which they are produced, belong to the genus *Anisopteryx*,[51] so named because in some species the wings in the two sexes are very unequal in size, and in others the females are wingless. In the late Professor Peck's "Natural History of the Canker-worm," which was published among the papers of "the Massachusetts Society for Promoting Agriculture," and obtained a prize from the Society, this insect is called *Phalæna vernata*, on account of its common appearance in the spring, and also to distinguish it from the winter moth (*Phalæna* or *Cheimatobia brumata*) of Europe.

Harris then describes "the male canker-worm moth," and continues:

This is the usual appearance of the male, in its most perfect condition; by which it will be seen that it closely resembles the *Anisopteryx Æscularia* of Europe.

After comparing these two males, he says:

Specimens, of a rather smaller size, are sometimes found, resembling the figure and description given by Professor Peck, in which the whitish bands and spot are wanting, and there are three interrupted dusky lines across the fore-wings, with an oblique blackish dash near the tip. Perhaps they constitute a different species from that of *the true canker-worm moth*.[52] Should this be the case, *the latter*[52] may be called *Anisopteryx pometaria*, or the Anisopteryx of the orchard, while the former should retain the name originally given to it by Professor Peck. The female is wingless, and its antennæ are short, slender, and naked. Its body approaches to an oval form, but tapers and is turned up behind. It is dark ash-colored above, and gray beneath.

This is the first intimation that we have of the existence of more than one species of Canker Worm, and this relates only to the differences to be observed in the males, no differences in the females being indicated. It will be noticed here, moreover, that Harris applies the designation, "true canker-worm moth," not to the species first called the Canker Worm by Peck, but to the larger species (*pometaria*) now described for the first time. This use of the name is very apt to mislead, for we should expect to find the term "true Canker Worm moth" applied to the species described as such by Professor Peck, and not, as Harris here applies it, to the other species. Indeed, most subsequent writers, including Fitch,[53] Packard,[54] Mann,[55] and Riley,[56] were misled by the language, and took it for granted that the name *pometaria* was proposed for the smaller form, while even Dr. Harris himself was so little convinced of the distinctness of the two species that, as Mr. Mann has shown,[57] he did not separate the specimens in his collection, and still applied the name *vernata* to both the forms.

So long as the male moths only were carelessly compared, there would always be a question as to whether the differences were varietal

---

[51] Literally *unequal wing*.
[52] The italics are our own.—C. V. R.
[53] 3d Rept. Ins. N. Y., § 38.
[54] Guide to study of Ins., 3d ed., p. 324.
[55] Proc. Bost. Soc. Nat. Hist., v. 15, p. 382.
[56] 6th Rept. Ins. Mo., p. 29.
[57] Proc. Bost. Soc. Nat. Hist., v. 16, p. 208.

or specific—1st, because the general resemblance is strong; 2d, because each species varies considerably both in size and ornamentation; 3d, because the wing-scales, especially of one species, easily rub off, and perfect specimens, captured at large, are uncommon.

It was not until the year 1873 that the distinctness of the two species was clearly established. More careful comparisons made at that time by Mr. B. P. Mann showed essential and very striking differences between the two species in both sexes, but the previously universal confusion regarding the application of the respective scientific names was not noticed until Mr. H. K. Morrison, having consulted Professor Peck's original paper, with Mr. Mann's discriminations in view, called attention to it.[58] As a consequence of this confusion no reliance can be placed upon the use of any name previous to 1874, as a means of discriminating between these species.

In his "Monograph of the Geometrid Moths," published in 1876 under the auspices of Dr. Hayden's Geological Survey of the Territories, Dr. Packard commits the same error that we had committed in our Sixth Missouri Report in concluding that Harris's *pometaria* is Peck's *vernata*, although the misleading nature of Dr. Harris's language regarding the two species had been pointed out in the meanwhile.[59] Under this misapprehension he has substituted the name of *autumnata* for *pometaria*, though it is evident that the former name cannot obtain,[60] and, in fact, in the introduction (pp. 8, 23, 39) to the Monograph the names *pometaria* (not *autumnata*) and *vernata* are used.

In his first paper on this subject[61] Mr. Mann gave reasons for believing that *vernata*, true to its name, is purely vernal in habit, and does not issue in the fall, while *pometaria* issues, for the most part, in the fall of the year. In general this seems to be true, although during mild winters, in the western and southwestern parts of the country, some adult individuals of *vernata* do appear in the fall of the year in which they have attained their growth as larvæ. In consequence of the general truth of these distinctions, however, we proposed, in 1875, for *Paleacrita vernata* the vernacular name of the Spring Canker Worm, and for *Anisopteryx pometaria* that of the Fall Canker Worm, and shall presently treat of each separately under these names.

The following synonymy of the combined genera is given by Packard:[62]

Erannis Hübn. (in part), Verz., 320, 1818.
Alsophila Hübn. (in part), Verz., 320, 1818.
Fidonia Treits. (in part), Schm. Eur., vi (i), 262, 1827.
Hibernia Dup. (in part), Lep. France, vii (iv), 301, 1829.

---

[58] Can. Entom., v. 6, pp. 29–32.
[59] Proc. Bost. Soc. Nat. Hist., v. 16, p. 207; Trans. Acad. Sci. Saint Louis, v. 3, p. 278.
[60] Trans. Acad. Sci. Saint Louis, v. 3, p. 575.
[61] Proc. Bost. Soc. Nat. Hist., v. 15, pp. 381–384.
[62] Monograph of the Geometrid Moths, pp. 398–399.

Anisopteryx Steph., Nomencl. Br. Ins., 43, 1829.
Steph., "Cat., ii, 116, 1829."
Steph., Ill., iii, 151, 1831.
Boisd., Gen. Ind., 193, 1840.
Anisopteryx Dup., Cat., 235, 1844.
Alsophila Steph., Cat. Brit. Lep., 160, 1850.
Anisopteryx Lederer, Verh. Zool. Bot. Ges. Wien, 177, 1853.
Guenée, Phal., ii, 254, 1857.
Walk., List Lep. Het. Br. Mus., xxiv, 1162, 1862.
Paleacrita Riley, Trans. Acad. Sc. St. Louis, iii, 273, 1875.

In 1860, Francis Walker described in the *Canadian Naturalist*, v. 5, p. 263, a moth, which he called *Anisopteryx restituens*, and which had been received from Canada. He repeated the description in his List of the Specimens of Lepidopterous Insects in the Collection of the British Museum, pt. 26, p. 1696. The following is the English of the latter description:

Male. Dark cinereous. Antennæ very slightly pectinated. Abdomen with a yellowish tinge. Wings cinereous, with a slight blackish discal mark, and with black marginal points. Fore wings with two indistinct, undulating, dark cinereous whitish-bordered lines; costa dark cinereous. Length of the body, 5 lines; of the wings, 14 lines. Canada. In Mr. D'Urban's collection.

Dr. Packard says that this is probably *Anisopteryx vernata;* but we see no reason to doubt that it is *pometaria.*

In 1862, Francis Walker described in his List of the Specimens of Lepidopterous Insects in the Collection of the British Museum (pt. 26, p. 1697), a moth which he called *Anisopteryx sericeiferata*, the English of which description is as follows:

Male. Dingy cinerous. Palpi extremely short. Antennæ minutely setulose and pubescent. Hind tibiæ with four moderately long spurs. Wings elongate, silky; fringe long, full. Fore wings somewhat rounded at the tips, minutely speckled with black, with four diffuse oblique more or less interrupted and indistinct brownish lines; an oblique apical blackish streak; discal ringlet brownish, indistinct, sometimes obsolete; exterior border slightly convex, rather oblique. Hind wings without markings. Length of the body 5 lines; of the wings 16 lines. *a–e.* United States. Presented by E. Doubleday, Esq.

Dr. Packard says that this is undoubtedly *A. vernata*, and we agree with him.

PAST HISTORY.

There are many insects, of which the Canker Worms are examples, which ordinarily occur in about the same numbers for a series of years, and then, in a particular season and in a particular locality, seem to be all at once swept from off the face of the earth. These phenomena are due to several different causes, but principally to the variations and irregularity in the action of cannibal and parasitic insects.

Owing to the confusion which has existed in regard to the two species, it is well-nigh, if not quite, impossible to separate their histories.

From Samuel Dean's "The New England Farmer; [etc.]," published at Worcester, Mass., in 1790, we learn that "it is not less than about fifty years since this insect [the Canker Worm] began its depredations

in New England, in parts which had been the longest cultivated." Hence, we may infer that the Canker Worms, of one species or the other, have been a scourge in this country since 1740, if not from an earlier date.

Mr. Peck says that "The Canker Worm is said to have been observed first in the Southern States, where it is probably a native. It is certain it must be spread by some means independent of itself, since the female, by the privation of wings, is forbidden to range. It may have been introduced into New England by the importation of trees from the Southern States, on which the eggs were deposited; or disseminated in the larva state, in all populous parts of the United States, by falling from trees upon carriages and travelers passing under them. This conjecture is rendered probable by its being found in all places which have intercourse with such parts as are infected with it, and by its being unknown in new settlements." But no authority is given for the assertion that the insects came from the South, and as they seem never to have occurred in the region which Peck intended by that word—*i. e.*, the Southern Atlantic States—the assertion must be discredited. Mr. Peck made his observations on *vernata* in Kittery, Me., probably in 1793 and 1794, or not long previous to those years, for it was first in 1793 that a prize was offered for the natural history of the Canker Worm, and he states[63] that on the 17th of May, 1794, the night was so cold as to produce ice one-third of an inch thick; at that time a great part of the Canker Worms were hatched; to these the frost was so fatal, at Kittery, Me., where he lived, that very few were seen in 1795. He paid diligent attention at the season of their rising, but found not one female, and saw but one male by accident, on the 6th of April. He says he earnestly wishes that this check, seconded by the endeavors of man, may extirpate this destructive insect.

Although he refers to the appearance of some imagos in November, it is not probable on any other grounds that he met with *pometaria*, as we might have expected him, if he had collected both species, to notice the differences between them when he was drawing up his original descriptions.

Mr. Mann suggests[64] that the *vernata* was crippled by this disaster of 1794, and did not afterwards, at least for many years, recover its former predominancy, its place being taken, when Canker Worms again appeared, by *pometaria*.

Assuming for the time [he says] that whenever any fall imagos are mentioned that *A. pometaria* is referred to, we find that *A. pometaria* was comparatively rare when Peck was making his observations, while *A. vernata* was "one of the most obvious and destructive of the insects that inhabit the apple-tree." The Massachusetts Society for Promoting Agriculture offered a large premium in 1793 for a satisfactory natural history of the Canker Worm, and another for a method of destroying the Canker Worm. The former premium was quickly secured by Mr. Peck, and a lesser one by Mr. Atwater, but the latter offer remained open and unsatisfied, from year to year, till

---

63 Mass. Mag., v. 7.

64 Proc. Bost. Soc. Nat. Hist., v. 16, pp. 206–207.

1813, when it was abandoned. The frost of 1794 seems to have been very effective, for it is not till 1801 that we find in the "Papers on Agriculture" of the Massachusetts Society for Promoting Agriculture, 1801, p. 4: "The Canker Worm has in some places made its appearance again," and in the "Papers" of the same society, 1807, p. 12, "Orchards have much improved of late [at Newbury, Mass.,] (since the year 1802), owing partly to the disappearance of the Canker Worm, and in the "Massachusetts Agricultural Repository and Journal," June, 1815, p. 316: "After having been freed for nearly twenty years from the ravages of the Canker Worm [at Roxbury, Mass.], our orchards are again overrun with them, and some of the most valuable trees of our country are threatened with destruction." Mr. J. Lowell, the author of the last quotation, says, *l. c.*, p. 317, "the insects rise in the fall."

Have we spanned the interval [Mr. Mann continues] within which the relative importance of *A. vernata* sank, and that of *A. pometaria* arose? In the journal last cited, January, 1816, Vol. IV, p. 89, Peck says: "It is certainly true that the canker moths rise in the autumn and deposit their eggs." But, he says, p. 90, "Those which rise in November are not very numerous, compared with those that rise in the spring." This certainly argues against my suggestion, if it is supposed to have been founded upon new observations, but not if it is merely a renewal of the statements made in 1795."

This suggestion by Mr. Mann seems, however, not to be confirmed by further investigation, for Mr. Morrison tells us, in 1874,[65] that *vernata* is much the commoner species [in eastern Massachusetts] and, he presumes, the most destructive. It seems to be evident, however, that *pometaria* was not an especially destructive species at the time of Mr. Peck's studies.

Dr. Wm. Le Baron, writing in 1871,[66] says that the Canker Worm "was very abundant in Massachusetts seventy years ago," which would place the time of this abundance in 1801, though some allowance may be made for the generality of the statement, and it appears from what he says immediately afterward that he may be referring to the years about 1793 and 1794; for "subsequently," he continues, "it became almost unknown in that State for many years. It is said to have disappeared after a very heavy frost in the month of June, which killed the caterpillars. But this is hardly probable of so hardy an insect as the Canker Worm."

Mr. Cyrus Thomas gives evidence, in 1876,[67] by published extracts from a letter to the *Western Rural*, of the Canker Worms having been very destructive insects in Connecticut about seventy years previously, in some seasons entirely divesting the trees of their foliage. This date may be doubtfully set down as occurring about 1806.

Dr. T. W. Harris, in a report on diseases and insects affecting fruit trees, published in 1854,[68] states that the insects prevailed in the vicinity of Boston, Mass., from 1831 to 1840, increasing yearly in numbers till the last date, but almost entirely disappeared from 1841 to 1847. They committed great devastations, however, in Dorchester, near Boston,

---

[65] Canadian Entomologist, vol. 6, pp. 29–32.
[66] Second Rept. Ins. Ill., p. 101.
[67] Sixth Rept. Ins. Ill., p. 21.
[68] Proc. Am. Pom. Soc., 3d sess., p. 210–218.

Mass., in or about 1844, when "they were so numerous that they could be heard traveling through the grass."[69]

In 1847, Harris continues, they reappeared, becoming more numerous every year until 1854 (the date of the report), when their ravages were very severe in Cambridge and adjoining towns, though they had not then reached the height attained in 1839.

There seems to be no evidence of the occurrence of Canker Worms in the so-called Western, or more properly Northern Central States, previous to 1852.

Mr. James Tucker states[70] that Canker Worms began attacking his orchard, in Warren County, Illinois, about 1852–1854, and their ravages continued till 1860, in which year they ceased; his trees "fruited well that year, and have ever since [till 1866] * * *; the worms hatched out as before, but died without doing injury." Mr. Tucker attributes the immunity from injury, which his trees enjoyed from 1860 to 1866, to the impregnation of the leaves with sulphur, which he inserted in the stem of the tree; but as this cannot be, some other reason needs to be assigned.

The occurrence of "the measuring-worm," which may or may not be a Canker Worm, at Edgerton, Williams County, Ohio, in 1860, is incidentally mentioned by E. A. F., in the *Prairie Farmer*, under date of July 24, 1860.

Mr. N. L. Hoover states[71] that Canker Worms destroyed the leaves and fruit of his apple trees, in Macoupin County, Illinois, every year from 1858 to 1861, inclusive.

N. G. C. states[72] that Canker Worms played sad havoc on the orchards in Monroe County, Iowa, in 1861, in some instances destroying both foliage and fruit.

According to Mr. Sanford Howard, secretary of the Michigan State Board of Agriculture, [73] the Canker Worm first appeared in the neighborhood of Marshall, Calhoun County, Michigan, in 1862, on two or three trees, in the orchard of Mr. Edwin Wilson, of Marengo. In 1866, these trees were dead, while several others, some of the largest and best in the orchard, were nearly dead, and the vitality of all the trees was so weakened that, though on many of them there were not worms enough in 1866 to do much injury to the foliage, they would bear no fruit. The ravages of the insect were obvious in 1866 in at least six different orchards in that neighborhood, and were spreading year by year. Where they prevailed in the greatest numbers in 1864 and 1865 they were less numerous in 1866. The cause of their diminution in their old haunts was obscure. Mr. Howard thought that perhaps the foliage was not sufficient in quantity in 1865 to carry to maturity all the worms that fed

---

69 Trans. Mass. Hort. Soc., for 1874, p. 22.
70 Prairie Farmer, [v. 33], n. s., v. 17, p. 211.
71 Prairie Farmer, v. 23, n. s., v. 7, p. 332.
72 Prairie Farmer, v. 23, n. s., v. 7, p. 401.
73 Pract. Entom., v. 2, pp. 6–7.

upon the trees, and that many of the starved larvæ died before they reached the perfect state, though, he says, it may be that the frosts and unusually cold weather which occurred in the spring of 1866, soon after the insects hatched, destroyed many of them. Means either of destruction or of prevention had not been much used. Mr. Howard says that, according to information published by Mr. Lyon, of Plymouth, in the *Western Rural*, the insect had appeared, in 1866 (?), in other localities in Michigan. They were very injurious in the Grand Traverse region of Michigan, in 1865 especially, and about the same time in other parts of that State.

Mr. J. W. Robson, of Tremont, Ill.,[74] says, in 1871, that the Canker Worm is not yet very common in the locality where he resides; that he discovered it in his orchard in 1865, and has seen it in other orchards in the same vicinity since then.

From statements by Mr. Wm. P. Lippincott, of Vernon, Van Buren County, Iowa, they occurred in that county in and previous to the year 1866.[75]

Bethune states[76] that the Canker Worm is related, in the *Canada Farmer* for May 1, 1867, to have been taken at Grimsby, Ontario, in the previous November (1866) by Mr. Johnson Pettit. Previous to this time it had not been included in the list of Canadian lepidoptera.

Mr. J. D. Dopf informs us that Canker Worms were exceedingly troublesome to the elms at Rockport, Atchison County, Missouri, in 1866.[77] In that year, according to Mr. B. D. Walsh, it had not yet reached the vicinity of Rock Island, Rock Island County, Illinois.[78]

R. P., of Mexico, Audrain County, Missouri, found it very injurious (in his county) in the spring of 1868.[79]

"A gentleman from Genesee," N. Y., is said[80] in 1874, to have become so discouraged in a six-years' contest with the Canker Worm that he finally cut down his orchard the previous spring [1873?].

E. F. Curtis, of Rockford, Winnebago County, Illinois, writing in 1872,[81] says that "the Canker or Measuring Worm, which made its appearance in this part of the country but a few years since, has been spreading rapidly, and now may be seen in almost every township in the Northwest."

Le Baron reports[82] serious damage by them from Clinton, Rock County, Wisconsin, and Duquoin, Perry County, southern Illinois, as well as from several intermediate places, in 1871. Reports of their injuries were communicated to the Department of Agriculture, at Washington,

---

[74] Western Farmer, May 13, 1871.
[75] Pract. Entom., v. 1, p. 96.
[76] Can. Entom., v. 1, pp. 88–89.
[77] Second Rept. Ins. Mo., p. 98.
[78] Pract. Entom., v. 1, p. 77.
[79] Second Rept. Ins. Mo., p. 97.
[80] New York Tribune, April 15, 1874.
[81] Iowa Homestead, Sept. 6, 1872.
[82] Second Rept. Ins. Ill., p. 101.

in May and June, 1871, from Norfolk County, Massachusetts, and from Jefferson County, Iowa.[83] Reports of the ravages of "black measuring worms," which may have been Canker Worms, on apple and fruit trees, were also sent to the United States Department of Agriculture, at the same time, from several counties in Ohio.

They are reported to have infested a few orchards in Plymouth, Mass., in 1874.[84]

E. Ware Sylvester states, in 1874, that *Anisopteryx pometaria* has nearly disappeared from his neighborhood [locality unknown], * * * the very general failure to put in an appearance being due to some cause not human.

Dr. Packard, referring presumably to the years about 1860 and previously, says that during several years' observations he had never observed *vernata* in Brunswick, Me., but in 1875 it was said to be for the first time injurious in orchards in that town.[85]

Prof. A. J. Cook said, in 1875,[86] that "this insect [*vernata*] has a curious history in Michigan; for though it has made its appearance several times, once in Calhoun County, again in Genesee County and in other places, for the past two or three years near Commerce, Oakland County, and just now near Pontiac of the same county, still it has never seemed to hold on; for, after destroying a few orchards, it seems to succumb to its natural enemies or unpropitious circumstances, and ceases to cause even anxiety."

THE SPRING CANKER WORM.

(*Paleacrita vernata*, Peck.)

The true Canker Worm, described as *Phalæna vernata* by W. D. Peck, in 1795, may be known, as already indicated (p. 164), by the popular name given above, from the circumstance that the great bulk of moths issue from the ground in early spring.

This is undoubtedly the species generally mentioned in the agricultural journals of the country, and is the one treated of in our Second report on the insects of Missouri as so injuriously affecting the apple orchards of Missouri and the States to the north and east of it.

RANGE OF THE SPECIES.

Formerly most abundant in New England, this Canker Worm is now found in many portions of the country, and of late years has been particularly injurious in the Northern Central States. Its range may be said to extend from Maine to New Jersey and westward to Wisconsin and southward in the Mississippi Valley to Texas. It is in fact the species best known in the Mississippi Valley, if not the only species which occurs

[83] Monthly Repts. [U. S.] Dept. Agric., for 1871, pp. 194–195.
[84] Monthly Repts. [U. S.] Dept. Agric., for 1874, p. 329.
[85] Packard, Monogr. of Geom. Moths, p. 404.
[86] Prairie Farmer, July 3, 1875.

there. We have specimens obtained by the late Jacob Boll near Dallas, Tex., which is the southernmost reliable limit in the West, while its northernmost recorded limit, west of Lake Michigan, is in Rock County, Wis. In Michigan it had in 1870 nearly reached the northern extremity of the southern peninsula. It does not seem to trouble the orchardists in the Atlantic States south of New Jersey, since it is not reported therefrom. Dr. Packard says:[87] "It is probable that it is indigenous to all parts of the country east of the Mississippi, but is abundant only locally originally along the coast of northeastern Massachusetts, and of late years in Illinois and Missouri"; but the evidence seems to show a progressive dispersion of the insect westward, doubtless by man's aid.

As might be expected from the wingless character of the females, their distribution is very unequal, and apparently arbitrary, a common road sometimes serving for years as a barrier between a free and an infested orchard. The evidence is conclusive as to the common occurrence of this particular species in Maine, Massachusetts, New York, Pennsylvania, Michigan, Wisconsin, Illinois, Iowa, Missouri, and Texas, but it is not so certain as to which of the two species the accounts from Canada, New Hampshire, Vermont, Rhode Island, Connecticut, New Jersey, Ohio, and Indiana refer to, though *vernata* in many instances is presumably the kind.

CHARACTERS.

IMAGO.—The Spring Canker Worm is distinguished in the perfect state by the first seven joints of the abdomen bearing each two transverse rows of stiff reddish spines, pointing posteriorly, more prominent in the female than in the male, and often giving the abdomen a reddish appearance. It is rather smaller in size than the Fall species, the male measuring from tip to tip of wings when expanded from about five-sixths of an inch [21mm] to over an inch and a quarter [32mm], and the female from a fifth to a little over a third of an inch [5–9mm] in length.

MALE.—The wings of the male are silky and delicate, the front ones marked with three transverse, jagged, dark lines, sometimes wanting, except on the front edge of the wing, where they are always more distinct, dividing this portion of the wing into four very nearly equal parts; they have also a somewhat jagged, pale, submarginal line. The upper surface is brownish-gray in color, while the hind wings are pale ash or very light gray, with rarely any dots or markings. Some specimens have no dots whatever, even when fresh from the chrysalis; and captured specimens, owing to the looseness of the scales, always have the marks more or less effaced. Indeed, the ornamentation of the wings is extremely variable. In many specimens the middle portion of the front wings, within the three dusky lines, is quite pale and mottled with grayish-green, while the basal and terminal portions are marked with brown, thus making the contrast greater.

FEMALE.—The body, legs, and antennæ of the female are clothed

[87] Monograph of the Geometrid Moths, 1876, p. 404.

with whitish and brown or black hairs, and along the middle of the back of the abdomen there is a black stripe, of which, sometimes, however, all but the ends is more or less obsolete. The color of the female is rabbit-gray, or speckled black and white. The abdomen is acutely tapering and ends in a two-jointed ovipositor.

EGG.—The eggs somewhat resemble in form hens' eggs, but are more elongated. They are very delicate in texture, yellowish, reflecting prismatic colors, and are smooth, though often appearing roughened by transverse and longitudinal irregular depressions.

LARVA.—The larva has but four prolegs, in addition to the usual three pairs of thoracic legs on the anterior portion of the body, these prolegs being situated on the 9th and the last joints of the body. (It may thus be distinguished from the larva of the Fall species, which has an additional short pair of prolegs on the 8th joint.)

The young larva is dark olive-green, or brown, with a black, shiny head. The full-grown worm varies greatly in the intensity of its markings, ash-gray, green and yellow ones occurring in the same brood. The most constant character by which it may be distinguished from other spanworms of the same size, is the pattern of the head, which, no matter what the general hue of the body may be, is usually shaded and marked as shown at Fig. 1.

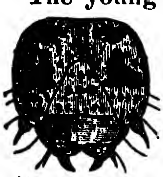


FIG. 1.—Enlarged head of larva of *Paleacrita vernata*.

Another distinguishing character is the occurrence of two pale, narrow lines on the middle of the back, the space between them usually being dark and occupied, on the anterior edge and on the middle of joints 5, 6, 7 and 11, by black marks somewhat in the form of X; these marks being represented by dots on the other joints. There are two rather prominent tubercles on top of the eleventh joint, preceded by two white spots.

The full-grown larvæ measure from seven to nine-tenths of an inch [18–23^{mm}] in length.

CHRYSALIS.—Pale grayish-brown, with a dark green tinge on the wing-sheaths. Remarkable for its robustness and for the large size and prominence of the palpi. A single bifurcate thorn at extremity. Length 0.35 inch [9^{mm}]; diameter across thorax 0.12 inch [3^{mm}]. Both sexes in the chrysalis state have wing-sheaths, those of the female being thinner than those of the male, and shorter, extending only to the posterior edge of the fourth joint of the abdomen, while in the male the wing-sheaths are one joint longer. The chrysalis of the male is more slender than that of the female.

The cocoons are simple earthen cells, slightly lined with silken threads, which are easily broken to pieces.

HABITS AND NATURAL HISTORY.

ISSUANCE OF THE MOTHS.—The moths or perfect insects rise from the ground, for the most part, early in the spring—generally from the

beginning of March to the middle of April, in the latitude of Missouri; two weeks later in Massachusetts—rarely coming out during the first mild weather that succeeds the first frosts in November; and on warm days during the winter when the ground is thawed. Many which we bred in the winter of 1869–'70 issued during the warm weather of January.

Dr. Le Baron observed them in Illinois from March 7 to April 7, 1871.

Dr. Packard says that in 1875 none had appeared in his garden in Salem, Mass., before the 10th and 11th of April, the season having been a very backward one. During these two days, which were warm and fine, he counted about one thousand males and two hundred females, mostly stuck to the inked bands on fourteen apple and three elm trees. This is in the proportion of one female to five males. He says that he suspects that the males fly about one or two days before the appearance above ground of the females.

Mr. Mann says that of 16 dated specimens of the male, 1 was taken in March and 15 in April; of nine females, all were taken in April. He presents negative evidence, also, that the species does not appear in the fall or the winter in eastern Massachusetts, where his observations were made.

The moths are crepuscular in habit; that is to say, most active in the evening soon after dark. During the day they usually rest quietly and concealed, the front wings of the male, when at rest, being turned back, so as to entirely cover the hind wings, and overlap on their inner edges.

At the height of the pairing and egg-laying season, the females may be seen, in multitudes, making their way up the trunks of the trees, alone or attended by one or more of the males, hardly pausing for the caresses of their attendants, but pressing onward to fulfil the one purpose of their existence. The female, by means of her horny and extensile ovipositor, thrusts her eggs, to the number of from fifteen to one hundred and fifty, singly or in irregular masses, and with only enough of a glutinous fluid to attach them slightly to each other and to their surroundings, within some sheltered or secret place, usually near, sometimes even between the leaflets of the expanding buds, sometimes even close to the ground, on the trunk of the tree, oftenest under loose scales of bark. Sometimes the eggs are deposited in cracks in the wood, or in holes made by borers, and frequently in places where the young larvæ cannot possibly get anything to eat when hatched. They have been found in dried apples which adhered to the trees through the winter, and the female is very fond of availing herself of the empty cases of the Rascal Leaf-crumpler, *Acrobasis nebulo*.[88]

APPEARANCE OF THE WORMS.—The eggs hatch at about the time when the young leaves of the apple tree begin to push from the bud,

[88] [Figured in our Fourth Mo. Rept., p. 38, fig. 18.]

which is about the time the red currant is in blossom, and the larvæ acquire their full size in from three to four weeks thereafter.

Dr. LeBaron found a few young larvæ on the trees in Kane County, Illinois, about April 20, 1871, but he says they were evidently premature stragglers, as the foliage had then scarcely begun to open. But on April 27, the red currant being in pretty full bloom, and the leaves on some of the apple trees being half expanded, he found almost every tuft of leaves which he examined occupied by two or three minute Canker Worms. In the latitude of Saint Louis the worms have generally descended the trees and entered the ground by the middle of May, though some remain till about the first of June. About Lancaster, Lancaster County, Pennsylvania, they attain their full size in May, and go into the ground by the first of June. In New York they are said (if the species which occurs there is *vernata*) to commit their ravages during the last of May and first of June, so that they probably complete their growth toward the middle of June.

We amply proved during the summers of 1868 and 1869 that there is but one brood each year in Missouri, just as there is but one brood in Maine, and at whatever time the worms enter the ground they remain there as chrysalids all through the summer and fall months, and the great majority of them till the following spring. Some, indeed, Dr. Harris says, remain in the ground for a year longer than the bulk of the brood. A frost seems to be necessary to their proper development.

HABITS OF THE WORMS.—The little Canker Worms, on making their escape from the egg, cluster upon and consume the tender leaves, and on the approach of cold or wet weather creep for shelter into the bosom of the expanding bud or into the opening flowers.

They feed and migrate by day, remaining stationary during the night. Like most other span-worms they have the habit of resting in a stiff, straight posture, either at an angle of about 45° from or flat and parallel with the twig which they occupy, and in these positions easily elude detection. They are seldom ever noticed upon our trees till the riddled and seared appearance of the foliage tells of their presence. The leaves first attacked will be found pierced with small holes, which become larger and more irregular when the Canker Worms increase in size; and, at last, the latter eat nearly all the pulpy parts of the leaves, leaving little more than the midrib and veins.

Upon completing their growth, they either crawl down the tree or let themselves down by means of a silken thread, and burrow into the ground. Here, at a depth of from two to five inches, and usually within a radius of from four to eight feet from the roots of the tree, they form their cocoons, within two or three days after completing which they become chrysalids.

FOOD-PLANTS.—Packard thinks that the native food-plant of this

species is the elm, and, according to Mr. John Sears, of Danvers, Mass., the black ash [*Fraxinus sambucifolia*], both in deep woods and in the open meadow, as he has found the females ascending the trees; but it is usually more destructive to the apple, and at times to the cherry.

It is no proof, however, that the black ash is a food-plant, above all the native food-plant, that the females ascend the trees, for they will ascend sticks, fences, or any other object upon which they can climb.

Apple-trees seem to be their principal food-plant; for though, in Missouri, we have found the worms on plum and elm, we have never known them there to do as great injury to these trees as to apple.

MODES OF DISTRIBUTION.

Although the females are wingless, and can, in consequence, only crawl from place to place, the insect is able to spread rapidly, in localities where it appears in numbers, for the larvæ can pass from tree to tree without much difficulty. When full grown or nearly so, and dropping by their silken threads to the ground, the suspended worms are caught up by the winds and wafted to other trees, many of them swinging off upon their threads to considerable distances. While hanging from limbs above the traveled roads, moreover, they are often swept off by passing carriages, and are thus conveyed to other places.

Le Baron says, in his second Illinois report (p. 108):

> I saw some to-day [May 24, 1871] floating 30 feet from the tree. As the web by which they are suspended is scarcely visible, the worms often have the appearance of flying in the air. At the same time I could find very few worms on the trunk, showing that their normal way of migrating is not by crawling down the tree, but by floating off on threads.

The observations of Mr. Howell only confirm the previous statements as to the manner in which these pests are diffused over large tracts of country, particularly in the West, when high winds prevail. He says:

> Caught up by the gales while suspended upon their gossamer web, I have seen multitudes carried far away, flying, thus supported, for long distances.

ENEMIES.

Like most of our noxious insects, Canker Worms are subject to the attacks of cannibal and parasitic insects. They are also devoured by very many different birds, some of which for a time subsist almost wholly upon these pests. Hogs are very efficient in rooting up and devouring the chrysalids during the summer months.

Nothrus ovivorus, Pack. (Fig. 2), devours the eggs, probably of the Fall species.

The most common parasite which we found in Missouri infesting the larva of the Spring Canker Worm is a small, four-winged fly (*Microgaster paleacritæ* Riley).[89] After issuing from its victim the Microgaster larva spins its pale, greenish-white cocoon alone, and not in company.

[89] Notes on N. A. Microgasters. Trans. Acad. Sci., Saint Louis, vol. 4, p. 311.

The flies issue in May, and we have bred the same species from cocoons from Canker-Worm larvæ (doubtless *vernata*), received from Mr. J. Pettit, of Grimsby, Canada. About 10 per cent. of the worms which we have endeavored to breed have been destroyed by this parasite. Harris mentions the larva of another four-winged fly (probably *Microgaster*), which preys on the fatty substance of the Canker Worm, and weakens it so much that it is unable to go through its future transformations, and that of a two-winged fly belonging to the genus *Tachina*, which also infests the worms, destroying about one-third of them in Massachusetts. He says he has seen the former of these flies sting several Canker Worms in succession, and swarms of them may be observed around the tree as long as the Canker Worms remain. Their services, therefore, are doubtless very considerable, but it is impossible to say, from present information, upon which species they prey, or whether upon both. We also received from Mr. Pettit, in addition to the *Microgaster paleacritæ* which he found upon Canker Worms, at Grimsby, some net-work cocoons, inclosing each of them a parasitic larva, which had preyed upon the Canker Worm. Each dead Canker Worm was secured to the leaf upon which it rested by one of these cocoons, which seemed at first sight to be a cluster of eggs attached to the body of the Canker Worm.[90] From subsequent experience with the genus we have little doubt but that these were larvæ of *Euplectrus*.

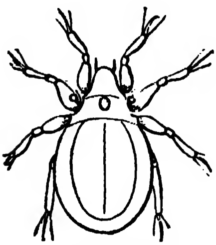


FIG. 2.—*Nothrus ovivorus* (after Packard).

The maggots of the *Tachina* parasite, mentioned by Harris, live singly within the bodies of the Canker Worms, till the latter die from weakness; after which they undergo a change, and finally come out of the bodies of their victims in their perfect form.

There is also a very minute and undescribed species of *Platygaster* (so called), first discovered by Mr. E. C. Herrick, of New Haven, Conn., which pierces the egg of the Fall species, and drops one of her own eggs into it, from which in due time the perfect fly develops. Sometimes every Canker Worm egg in a cluster will be found to have been thus punctured and seeded for a future harvest of the *Platygaster*. The young of this *Platygaster* is an exceedingly minute maggot, hatched within the Canker Worm egg, the shell of which, though only one-thirtieth of an inch long, serves for its habitation, and the contents for its food, till it is fully grown; after which it becomes a chrysalis within the same shell, and in due time comes out a *Platygaster* fly, like its parent. This last transformation Mr. Herrick found to take place towards the end of June, from eggs laid in November of the year before; and he thinks that the flies continue alive through the summer, till the appearance of the Canker Worm moths in the autumn affords them the opportunity of laying their eggs for another brood. As these little

[90] Amer. Entomologist, v. 1, p. 246.

parasites prevent the hatching of the eggs wherein they are bred, and as they seem to be very abundant, they must be of great use in preventing the increase of the Canker Worm. Without doubt such wisely-appointed means as these were once enough to keep within due bounds these noxious insects; but, since our forests, their natural food, and our birds, their greatest enemies, have disappeared before the woodman's ax and the sportsman's gun, we are left to our own ingenuity, perseverance, and united efforts, to contrive and carry into effect other means for checking their ravages.

Among the cannibal insects may be mentioned the Ground-beetles, two of which we have found preying upon the Spring species, namely, the Rummaging Ground-beetle (*Calosoma scrutator*, Fabr., Pl. 2, Fig. 4), a large and beautiful insect with golden-green wing-covers, and having the rest of the body marked with violet-blue, gold, green, and copper; and the Fiery Ground-beetle (*Calosoma calidum*, Fabr., Pl. 1, Fig. 8), a black species, of almost equal size, with copper-colored spots on the wing-covers. These beetles do not pursue their prey by flight, although they can fly, but they are very active, and run over the ground in search of soft-bodied worms, and will even mount upon the trunks of trees for the same purpose. Mr. Charles R. Dodge informs us that he was able to find either of these beetles, almost at any time during the Canker Worm season, upon the elm trees in New Haven, Conn., just below the tin bands with which the trees were protected. The 15-spotted Lady-bird (*Mysia quindecimpunctata*), he states, was also met with in the same situation earlier in the season.

"The Fraternal Potter-wasp (*Eumenes fraterna*, Say), is stated by Harris to store her cells with Canker Worms, often gathering eighteen or twenty of them for a single cell. This wasp (Fig. 3 *a*) is quite common in Saint Louis County, Missouri, and uses other species besides Canker Worms as food for its young. Its clay nest (Fig. 3 *b*, entire; *c*, the same cut open shortly after it was built, showing the manner in which it is compactly crowded with green worms) may often be found attached to the stems of the Goldenrod and of other plants in the open air, or cemented under the loose bark of some tree. It has even been found attached to the leaves of a deciduous plant, where it must necessarily fall to the ground in winter and lie there till the perfect insect issues in the following summer."[91]

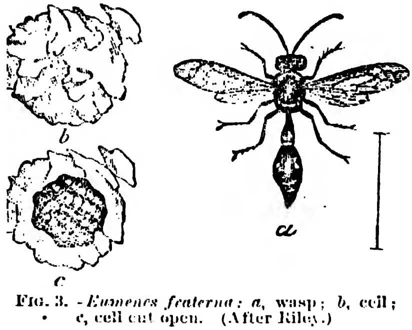


FIG. 3. -*Eumenes fraterna*: *a*, wasp; *b*, cell; *c*, cell cut open. (After Riley.)

The earliest record that we have of any bird being an enemy to Canker Worms is in Samuel Deane's dictionary,[92] where the name of the bird is

[91] 2d Rept. Ins. Mo., p. 103.

[92] New Engl. Farmer; or Georgical Dictionary: *verbum* Canker Worm.

not given. Probably this is the Cedar-bird (*Ampelis cedrorum*), which Professor Peck mentions in his prize essay as *Ampelis garrulus*.

Mr. J. W. Robson, in the *Western Farmer* for May, 1871, gave the following testimony as to the birds which destroy this worm:

The Blue-bird destroys large numbers, not of larvæ alone, but of fully developed moths in the fall, and again in the spring they return just in time to devour the insect as it emerges from the soil.

The Cedar-bird is another enemy. This little bird is a gross feeder, and when the Canker Worms appear in great numbers, as they sometimes do, it will come in large flocks and feed upon them day after day till the pest is subdued.

The Butcher-bird also feeds its young largely upon the larvæ. We well remember it clearing two trees literally covered with this caterpillar, and so well did that pair of Shrikes do their work, that these same trees have not been troubled with the insect since.

In the *American Naturalist* (v. 8, p. 271), Dr. Packard quotes Mr. C. J. Maynard, of Ipswich, Mass., who has examined the stomachs of some three thousand birds, as giving the following formidable list of species which devour the Canker Worm:[93]

In answer to your questions relative to birds eating Canker Worms and the larvæ of other injurious insects, I would say that upon examining my notes, I find that I have taken Canker Worms from the stomachs of the following species:

Red-eyed Vireo (*Vireo olivaceus*), Song-sparrow (*Melospiza melodia*), Chickadee (*Parus atricapillus*), Scarlet Tanager (*Pyranga rubra*), Robin (*Turdus migratorius*), Black-billed Cuckoo (*Coccyzus erythrophthalmus*), Wood Pewee (*Contopus virens*), Least Pewee (*Empidonax minimus*), Wilson's Thrush (*Turdus fuscescens*), Black and White Creepers (*Mniotilta varia*), Blue Yellow-backed Warbler (*Parula americana*), Maryland Yellow-throat (*Geothlypis trichas*), Nashville Warbler (*Helminthophaga ruficapilla*), Golden-crowned Thrush (*Seiurus aurocapillus*), Chestnut-sided Warbler (*Dendroica pennsylvanica*), Yellow Warbler (*D. æstiva*), Black-and-yellow Warbler (*D. maculosa*), Prairie Warbler (*D. discolor*), Black-polled Warbler (*D. striata*), Canada Warbler (*Myiodioctes canadensis*), Red-start (*Setophaga ruticilla*), Cedar-bird (*Ampelis cedrorum*), Cat-bird (*Mimus carolinensis*), Purple Finch (*Carpodacus purpureus*), White-winged Cross-bill (*Curvirostra leucoptera*), Chipping Sparrow (*Spizella socialis*), Indigo-bird (*Cyanospiza cyanea*), Red-winged Black-bird (*Agelaius phœniceus*), Cow Black-bird (*Molothrus pecoris*), Bobo-link (*Dolichonyx oryzivorus*), Baltimore Oriole (*Icterus baltimore*).

Other correspondents mention the King-bird, Purple Grakle, House Pigeon, all the Vireos, Downy Woodpecker, Summer Yellow-bird, Blue-bird, Golden-winged Woodpecker, Golden Robin, and Yellow-billed Cuckoo. With such a formidable array of feathered enemies, the sudden disappearance of the Canker Worm, for a term of years, from orchards where it was wont to play havoc, is no longer to be wondered at.

DESTRUCTIVENESS OF CANKER WORMS.

The apple and the elm trees have, perhaps, no enemies that cause a more effective and universal blight than the Canker Worms. Dr. Le Baron names the Spring species as one of the five enemies of the apple tree which hold a bad pre-eminence, and says that whilst looking at the apple trees blasted by these insects he was struck with the appropri-

[93] The determination of the species of the worms is, however, subject to much doubt.

ateness of their popular name, for in their earlier periods, by eating numerous irregular holes through the leaves, they reduce them to a skeletonized condition and interrupt the flow of sap, and the leaf becoming withered and brown before it is wholly eaten gives the tree the appearance of having been scorched with fire. Harris says it reduces the foliage of our fruit trees and of our noble elms to withered and lifeless shreds, and causes whole orchards to look as if they had been suddenly scorched with fire. Rathvon says that when the Canker Worms have overrun an apple tree, the leaves which they have not devoured will present the dry and browned appearance of a rose-bush that has been devastated by rose-slugs.

Mr. John Tinker, of Clinton, Rock County, Wisconsin, states[94] that apple trees will perish after having been defoliated three years in succession, and Dr. LeBaron says that in the fifth year in which the Canker Worms had appeared in the orchard in which he made his observations, some of the trees were dead and others were in a dying condition.

We know of few more discouraging sights than an orchard which has been badly injured by these pests, presenting as it does, in midsummer, the seared and blasted aspect that follows fire.

Where they have become established and are neglected, their ravages soon become very great, but our own experience, in Missouri and Illinois, would indicate that old orchards suffer most.

THE FALL CANKER WORM.

(*Anisopteryx pometaria* Harr.)

RANGE OF THE SPECIES.

There is no evidence that *pometaria* occurs at all anywhere in the Mississippi Valley, since an examination of the specimens of Canker Worms in Dr. LeBaron's cabinet, and in our own, proves them all to be the true or Spring species. Indeed, until we received specimens of *pometaria* from Mr. H. K. Morrison and Mr. Mann, we had never seen the species, the male specimens which we mistook for it in former years, being in reality specimens of *vernata*, which approach it in the markings of the front wings.

As Canker Worms are not very injurious in Canada, and occur, when at all, generally in October and November, our Canadian neighbors are doubtless afflicted with the Fall species.

The Fall species may be said to range from the eastern shore and the northern boundary of Massachusetts to the western extremity of the Canadian peninsula, between Lakes Ontario and Erie and the southern shore of Connecticut and Rhode Island. Probably its range is wider, but we only have reliable reports from about Salem, Boston, and Cambridge, Mass., and New Haven, Conn.

[94] LeBaron, 2d Rept. Ins. Ill., p. 109.

Morrison and Packard both say that it is much less common than *vernata* [in Massachusetts]. Bethune,[95] probably referring to this species, says that it is not often met with in Canada, the only native specimens he had seen having been found, by Mr. Johnson Pettit, at Grimsby, Ontario, during November, 1866, and the following winter.[96] Referring, evidently, to the same species, Saunders says, in 1875,[97] that the Canker Worms "are now becoming plentiful in portions of Ontario, particularly in some parts of the Niagara district."

CHARACTERS.

Under critical examination the Fall Canker Worm is readily distinguished from the Spring species. On the average the imago is somewhat larger and more glossy; the fore wings are a little more elongated toward the apex, making the outer edge a little longer and more oblique; they are of a peculiar ochreous-brown tint, as in the European *æscularia;* they have a distinct white spot on the front edge, and are crossed by two pale, jagged bands, along the sides of which are several blackish dots.

The hind wings have a more or less distinct, pale, curved line across their middle. The female is uniformly dark ash-gray above, paler beneath, and with naked antennæ; her legs and abdomen are smooth and glistening, and she has no extensile ovipositor.

Thus these imagos lack the characteristic dorsal spines of *vernata*, the dusky marks across the front wings of the male, and the pubescence in the female; and there are many other minor differences, which are mentioned in detail in the tabular and comparative description already given of the two insects.

We give the following detailed descriptions from the Seventh Entomological Report of Missouri.

ANISOPTERYX POMETARIA Harris—*Egg*—Length, 0.025 inch; average diameter two-thirds the length; flattened at top where it is somewhat larger than at base. Color of crown purplish-gray, the surface slightly corrugated, with a central dimple and a brown circle just within the border; sides smooth and more silvery, and generally somewhat compressed by pressure of adjacent eggs. Laid in exposed situations, in patches or strips, attached in regular rows, and fastened to the bark in a slightly slanting position so that one edge of the crown is a little above, the other a little below the general level.

Larva—Color pale-brownish, marked with dark brown and yellow as follows: The dorsum uniformly dark brown; the sides with three pale narrow lines, more or less irregular and mottled, but always well relieved, the two superior ones white, the lowermost yellowish; the subdorsal space between the upper two of these lines, pale; the stigmatal between the lower two darker, especially in middle of the joint around stigmata; the thoracic joints dark with the pale lines somewhat narrower and running up to the head. On joint 11 these lines are constricted or entirely broken, so as to leave a dark band across the middle of the joint. The head is dark brown above and at sides, but paler in front. Cervical shield also dark with the yellow lines run-

[95] Canada Farmer, v. 4, p. 133.
[96] Rept. Fruit Grower's Assoc. Ontar., for 1870, p. 86.
[97] Sixth Ann. Rept. Entom. Soc. Ontar., for 1875, p. 27.

ning through it. Venter olivaceous, the legs more reddish, there being three pairs of prolegs, the pair on joint 8 only half as long as those on 9, but with perfect hooklets; the thoracic legs quite hirsute and terminating generally in two thorns. Piliferous spots obsolete and with a very few scarcely distinguishable pale hairs, except on anal shield and legs, where they are stouter. Anal shield and legs with brown piliferous dots. The larva when first hatched is yellowish-white, with the black eyelets showing distinctly on the pale head. It soon deepens to pale olive green, with a large pale-yellowish head and pale legs. The light lines of the mature larva are, at this early stage, faintly indicated and the piliferous spots give forth short, fleshy, pale hairs. The third pair of prolegs is distinctly visible, but is not used in locomotion. After the first molt the head and thoracic legs become somewhat browner, and the olivaceous green more bluish. After the second molt, the dark colors show much more distinctly.

Described from numerous full-grown specimens received from Mr. B. P. Mann, others received from Dr. A. S. Packard, jr., and a large number of all ages reared by myself from the egg.

It varies somewhat in intensity of color, and in some the light and dark browns are not so sharply separated, but the dorsum is generally uniform and the three lateral yellow lines distinct. Up to the second or last molt, the general color is, with rare exceptions, greenish; but in the last stage, the dark-brown or black predominates, and is sometimes so general that there is but the faintest trace of the superior yellow lines. Occasional specimens, even when young, show in the subdorsal dark space one, and in the dorsal dark space two, very fine and faint pale lines. Differs entirely from *vernata* in lacking most of the characteristic spots in front of the head of that species, and the two pale transverse marks; in having the dorsum darker instead of lighter than the rest of the body; in lacking the medio-dorsal pale lines and the characteristic x-like marks; in the broader, more conspicuous pale lateral lines, and in the subdorsal space being darker than the stigmatal; and lastly in the additional, though atrophied, abdominal prolegs. It is a smoother larva.

Chrysalis—Color light brown, with the wing-sheaths, a medio-dorsal shade, sutures and stigmata darker. Length 0.30–0.35 inch; stout, with the wing-sheaths and their veins distinct in the female; a dorsal, bifid, decurved tubercle near the tip of anal joint.

HABITS AND NATURAL HISTORY.

In many particulars the habits of this species and those of the Spring species are similar. We will mention here more particularly those habits wherein the Fall species differs from the other:

ISSUANCE OF THE MOTH.—The moths rise from the ground, for the most part, late in the fall of the year—generally beginning about the middle or latter part of October—although a considerable number come out of the earth in the winter during warm weather and in spring.

Of twenty-seven chrysalides from which we obtained moths in 1875, a portion of the cocoons being placed in a covered flower-pot outdoors so that they might be submitted to the influence of frost, and another portion being retained in breeding cages indoors, so as not to be affected by frost, the former began to issue first, and a larger percentage of moths were obtained from that portion than from those kept indoors—which would indicate that a low, freezing temperature, followed by a thaw, assists development, though by no means essential. These moths, two of which were males, and twenty-five females, issued almost daily from November 8 to December 9.

Mr. Mann says:[98] Of sixteen dated specimens of the male, twelve were taken in October or November, and four in March or April. Of several hundred females, four were taken in April and the rest in November. Again, he says that he has captured imagos during every week from the last week of October to the middle of January, inclusive, in the last week of March, and in the second, third, and fourth weeks of April.

Under conditions of confinement we have observed that two males mated with five females; whether the males are polygamous in a state of nature we cannot say. It would seem, however, from the circumstance, that out of fifty-eight chrysalides, fifty-six were females, that such was the case to an eminent degree.

OVIPOSITION.—In depositing her eggs, the mother-moth does not hide them away under the loose scales of bark, or elsewhere, as is the habit with the female of the spring species, but lays them in the forks of the small branches, or close to the young twigs and buds, or on the bark of the trunks of the trees, in regular, compact batches of from 60 to 200 eggs, placed in a single layer upon their ends, side by side, firmly fastened together and to the bark by a strong glue, and coated with a grayish, water-proof varnish. From five impregnated females, which we raised in confinement in 1875, we obtained the full complement of eggs, which were laid, by four females in single batches of 224, 230, 241, and 243, respectively, and by one female in two batches of 142 and 63, respectively. The first four batches were laid on the smooth pine sticks that supported the muslin cap of the breeding cage; the last two on the muslin. In each instance the time occupied in oviposition was between two and three days. None of the unimpregnated females which we raised laid regular batches. Most of them laid a few scattered eggs, generally singly, but also in small groups ranging from 2 to 54.

Immediately after the insects have thus provided for a succession of their kind, they begin to languish and soon die.

SEASON OF APPEARANCE OF THE WORMS.—Although the eggs are laid at such different periods, during fall, winter, and spring, they do not hatch any earlier than those of the spring species. The larvæ, at first minute and thread-like, appear as the leaves begin to form, develop very rapidly, and with favorable weather enter the ground to form their chrysalides within three weeks after hatching. Harris says that the eggs are usually hatched between the first and middle of May, and that in the vicinity of Boston the larvæ do not become extremely voracious until June. "In the year 1841, the red currant flowered, and the Canker Worms appeared, on the fifteenth of May. The insects were very abundant on the fifteenth of June, and on the seventeenth scarcely one was to be seen."

Dr. Packard says that "on the 9th of April, 1875, the eggs of this

[98] Proc. Bost. Soc. Nat. Hist., v. 15, p. 384.

species were not developed unless in a very early stage of the embryo." Specimens of the larvæ were gathered by him June 15.

Mr. Mann found the larvæ descending from elm and apple trees on the 17th of June, 1872.

It is a singular fact that the larva undergoes but two molts exclusive of that which takes place underground in the transformation to the chrysalis.

SEASON OF PUPATION.—The chrysalis is not formed till about a month after the larva has entered the ground.

FOOD-PLANTS.—This species is found more particularly on the elm, and occurs also on the apple, but in our experiments upon larvæ kept in confinement, in 1875, we did not perceive that the larvæ had any preference for one over the other of the leaves of elm, apple, and cherry, though they evidently relished peach leaves the least, and rejected them when the other three kinds could be had.

One or the other species—it is uncertain which—attacks the maple.

REMEDIES AND PREVENTIVE MEASURES APPLICABLE TO BOTH SPECIES.

It may be laid down as a maxim that no injurious insect can be combatted successfully without a thorough knowledge of its habits and transformations. This knowledge having been conveyed in the preceding pages, we will now consider what are the proper remedies for the ravages of these insects. The absence of wings in the female gives us at once a power over her which is half the victory; and anything that will prevent her ascending the trunk will, in a great measure (but, as we shall see presently, not entirely), preserve the tree from the ravages of the worm.

In the following account the author's previous writings have been largely drawn upon, and parts in quotation marks not accredited are taken therefrom. The remedies are appropriate for either species here considered, though they should be applied most assiduously either in spring or autumn, according to the species to be dealt with.

STICKY SUBSTANCES.

Numerous indeed have been the devices—patented or unpatented—which have at different times and in different parts of the country been used to accomplish the desired end; and every year our agricultural journals report individual experiments with some one or other of these devices—some favorable and others adverse. Those most generally in use have consisted of some application of a sticky nature to the trunk of the tree, whereby the feet of the moth may be encumbered and from which she may be unable to escape. Various substances have been used for this purpose, of which I will mention tar, bird-lime, refuse sorghum molasses, printers' ink, slow-drying varnishes, and melted india-rubber; this last always retaining its soft viscid state, while the rest become dry and hardened by exposure to the air.

The editor of the *New England Farmer* thinks that oil and rosin, boiled together in certain proportions, which have to be ascertained by "the rule of thumb," answers a better purpose than tar, because it does not dry up so much on hot days, and therefore does not require to be renewed every day, as tar does.

The methods of application of these substances have been as diverse as the substances themselves. They have been applied either directly around the body of the tree, or over a broad belt of clay-mortar, or on strips of old canvas, on sheep-skin, on stiff paper, on the under side of a horizontal and close-fitting collar of boards fastened around the trunk, or on four boards nailed together, like a box without top or bottom, around the base of the tree, to receive the application on the outside.

Whatever substance is used must be renewed as often as it becomes dry or as the surface ceases to be sticky or becomes coated with a mass of captured moths.

It cannot be denied that it requires a great deal of time, labor, and expense to continually renew these applications on every tree in a large orchard during so many months of the year; while the application of tar directly to the bark is more or less injurious to the trees. For these reasons, refuse sorghum molasses will be found much better than tar for the purpose, as it does not harden so rapidly, and is said not to be injurious to the tree. In neighborhoods where sorghum is grown, it is also much cheaper. It may be thickened with flour to bring it to the right consistency for use. If tar is used, it should be entirely scraped from the bark when the season for which it was needed is over; and if bandages are used they should be removed at the same time. That it will pay to do this work in orchards where the Canker Worm is known to be numerous, there cannot be the least doubt. The old adage, "What is worth doing at all is worth doing well," was never truer than in fighting this insect.

Mr. B. D. Walsh calculates the cost and the profit in the following way:[99]

> To head the Canker Worm, therefore, effectually, the trees must be tarred afresh every day from the latter end of October to the middle of May, or to about the time that the apple leaves are completely put forth, omitting to do so on cold days in the dead of winter. Call the whole net time 150 days, to be on the safe side. A man could certainly tar 100 trees in an hour, which would make 150 hours, or fifteen days' work for saving the apple crop of 100 trees. Put work as high as you please and apples as low as you please, and the operation, viewed as a question of dollars and cents, is most certainly a paying one.

"Apply the remedy thoroughly during two successive years, and you have utterly routed the enemy, and this is more especially the case where an orchard is not in too close proximity to the timber, or to slovenly neighbors. Fail to apply the remedy, and the enemy will, in all probability, rout you. The reason is simple. The female being wingless, the insect is very local in its attacks, sometimes swarming

[99] Pract. Entom., v. 2, p. 17.

in one orchard and being unknown in another which is but a mile away. Thus, after it is once exterminated, a sudden invasion is not to be expected, as in the case of the Tent Caterpillar and of many other orchard pests; but when it has once obtained a footing in an orchard, it multiplies the more rapidly, for the very reason that it does not spread fast."

An account is given in the *Western Rural* of a very good plan adopted by a Mr. Smith, of Des Moines, Iowa, for applying coal-tar, molasses, or other sticky substance. He first makes a slight mound of earth around the tree, smoothing it at top; brown wrapping-paper, to be smeared, is then tied around the tree and turned down over the mound. The moisture of the earth prevents too rapid drying of the tar, and the plan proves at the same time a preventive of the Round-headed Borer.

"For those who wish to do work thoroughly while they are about it, and who believe that a little extra time and expense at the start is more than saved in the long run, I do not know that any better contrivance could be recommended than the hanging tin band described below. But I would remind the reader that even so perfect an 'estopper' as this may measurably fail if directed solely against the moths. The worms that hatch below the trap, and which are more difficult to manage, must also be headed off; and I would insist, in pursuance of this object, that, in addition to the directions given for its use, the muslin be tied around the tree over a layer of cotton wadding, and that the contrivance be kept on the tree and the tin oiled at least three weeks after the tree begins to leaf out in the spring. The eggs laid below the trap should, of course, be destroyed as far as they can be, and such destruction in dealing with the spring species will be facilitated by a bandage of rags below the trap, or by anything that will afford the moth shelter for her eggs and that can be easily removed and scalded; where no such lure is used, an application of kerosene will prevent the eggs laid on the tree from hatching. But some are likely to be laid where they escape the closest scrutiny, and while the precautions I have indicated will insure against the ascent of such, whether from the Fall or Spring species, without those precautions some of the newly-hatched worms, which can pass through a very minute crevice or over the smoothest surface, may get into the tree; and though they may be so few in numbers as to attract no attention, they nevertheless perpetuate the species in the orchard."

HANGING TIN BAND.

This hanging tin band was first described in the *Cultivator and Country Gentleman* for May, 1873, and afterward in the *Illustrated Annual Register of Rural Affairs*, published by Luther Tucker and Son, of Albany, N Y., and is very favorably spoken of by that careful horticultural writer, Mr. J. J. Thomas. It has been used successfully by C. L. Jones, of Newark, N. J., and we should advise the use of it, if kept properly oiled, over all forms of troughs whatsoever, for they too often

get filled up with the dead bodies of the moths or with leaves, or get bridged with spider-web; and where fastened directly around the tree must needs be renewed as the girth of the tree increases.

Fig. 4 represents the contrivance, "which consists essentially of a band or circle of tin, a few inches outside the trunk of the tree, and held there by a circle of muslin, attached to the tin at its edge and drawn with a cord at the top, so as to fit the tree closely and prevent the insects from getting up without going over the tin, covered with a mixture of castor-oil and kerosene; as soon as they touch this, they drop to the ground. Fig. 5 is a section of the contrivance, and Fig. 6 a section of the union of the tin and muslin, effected by turning over the upper edge of the tin before it is bent to a circle, inserting the edge of the muslin, and hammering them together. The tin may be about three inches wide, and long enough to rest three or four inches off from the trunk, when bent around in the form of a hoop, and secured by rivets or small tacks.

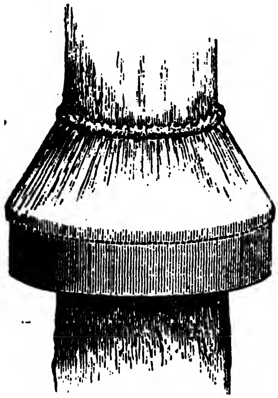


FIG. 4.—Canker-worm trap.

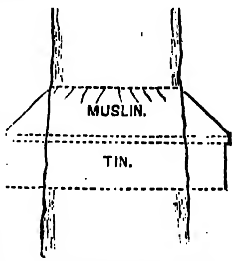


FIG. 5.—Section of canker-worm trap.

After the tin and muslin are attached to the tree, the whole inner or lower surface of the tin is daubed with a mixture of equal parts of kerosene and castor-oil. The tin and muslin entirely protect the oil from the sun and the weather, and it will not dry for several days. It will not run down, as the castor-oil thickens it. Of course it needs occasional renewal, with a small brush or feather. This protector is kept on the tree till the moths disappear."

TROUGHS OF OIL.

Another remedy, calculated to prevent the moth, and the larva as well, from ascending the tree, is the use of a trough to contain some substance, usually of an oily nature, which kills the insects as they come in contact with it. These troughs are made of tin, lead, rubber, iron, or other substances. The principal objections to their use are their cost, the difficulty of fixing and keeping them in their places, and the injury suffered by the trees when their contents are washed or blown out and fall on the bark. They ought not to be nailed, as the nails are found to be injurious to the trees, but should be supported by a few wooden wedges, driven between them and the trunks. A stuffing of sea-weed or fine hay, which will not absorb oil, is much better than one of cloth, cotton, or tow. Before the troughs are fastened and filled, the body of the tree should be well coated with clay-paint or white-

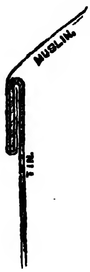


FIG. 6.

wash, to absorb the oil that may fall upon it. Care should be taken to renew the oil as often as it escapes or becomes filled with the insects. These troughs, though costing more, will be found less troublesome than tar, and may safely be recommended and employed, if proper attention is given to the precautions above named.

If oil-troughs are used, it will be found much safer and surer to sink them in the ground close around the butt of the tree than to wind them around the trunk higher up. There will then be no chance for the young worms to get up between the trough and the tree, and all danger of hurting the tree with oil or tar is entirely avoided.

The following description of a trough of this kind is taken from the report of a committee chosen to award a premium of $100, offered in 1871 (?) by the Essex (Mass.) Agricultural Society, for a "new, cheap and effectual remedy against the ravages of the Canker Worm":

> The protector used by Mr. Sawyer is simply a trough or gutter laid upon the ground around the tree, and filled with coal-tar from the gas-works. The troughs used by Mr. Sawyer are made of two-by-three joists, sawn from two-inch plank. A channel an inch or more deep and an inch and a half wide is grooved out, and the stock is then sawed off in a miter-box at suitable lengths for different sized trees, and the pieces nailed together, one side slightly, so that it can be easily removed when placed around the tree. A square box or trough is thus made which is laid level on the ground around the tree. The space between trough and tree trunk is filled with dirt, the trough itself filled with coal-tar from the gas-works, and the work is done.

The tar has rosin oil mixed with it, and is stirred up or replenished three or four times in autumn, and the same in spring.

"On plowed land it is easy to level up the earth around the tree, but on grass-ground it may be necessary to carry sand or dirt on which to place the trough. The troughs first used by Mr. Sawyer had a cover of boards to prevent the rain and leaves from getting into the tar. But he finds the plain troughs just as effective at less than half the expense, although they require a little more care. He states that he made his troughs himself, and that they cost from twelve to seventeen cents per tree. Of course they can be made from the cheapest, coarsest plank, and after they are laid down the tar will help to preserve them many years.

"The cost of the coal-tar is said to be small. Mr. Sawyer states that he found it necessary to stir the tar but two or three times in the spring or fall, and that few troughs required refilling. At the time of holding the annual fair in Gloucester, he told us that by stirring the tar, then in the troughs, many of them would effectually bar the passage of the grub. These statements seem to show that the trees will require but little labor or expense for several years after the troughs are put down. The testimony of other parties who have used these troughs is unanimous as to their effectiveness when properly used.

"The troughs used by Mr. Leach differ from those of Mr. Sawyer only in having a triangular channel, which Mr. Sawyer admits to be an improvement. Mr. Leach thinks his troughs can be furnished ready

for the trees at 25 cents each, as orchards average. Of course the expense will depend largely on the quality of the lumber used."[100]

Another contrivance is an old one that has been employed for nearly forty years in Massachusetts, and lately used with satisfaction by Mr. John G. Barker (when gardener to Mr. G. G. Hubbard), of Cambridge.

Fig. 7 is a section of the whole contrivance—*a a* being the zinc roof over the oil troughs, *b b*; *d d*, the surface of the earth; *c c*, the tar or lime which is used to fill the box around the tree.

Fig. 8 is a smaller view of the same. The box is square, large enough to leave about four inches of space around the tree; is sunk some four inches in the ground, and rises about ten inches above the surface. The trough is in shape like the letter V, two inches deep, and is made

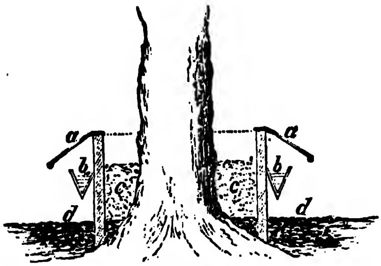


FIG. 7.—Canker-worm trap.

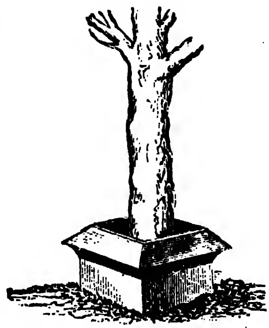


FIG. 8.—Canker-worm trap—section.

by a tinman before nailing on the box; it is tacked on two inches below the upper edge of the box, and then the roof is placed in position and secured by a single screw into the upper edge of each side or board. It must, of course, be placed in a level position, to hold the oil. This is done by means of a spade used in setting the box in the earth. The box and roof are nearly completed in the tinshop, but the corner of both must be left open till placed around the tree, when the parts are soldered together. The roof is about four and a half inches wide, with the outside turned under about the fourth of an inch, to keep it stiff and in shape. In order to examine the oil, and to see that all is right, it is necessary to loosen one of the screws. The box will vary somewhat in size with the magnitude of the tree; with a trunk six inches in diameter, the box should be about fourteen inches square and fourteen inches high; for a trunk a foot in diameter, it should be about twenty inches square; but a variation of two or three inches would not be of great importance. A few inches of tan-bark or lime placed within, is for the purpose of preventing the moths from ascending inside. One pint of crude petroleum (costing 3 cents per tree, at 24 cents per gallon) is enough for each tree.

With a little care in making a close connection between the V-shaped trough and the box, the above contrivance must work to perfection, as indeed Mr. Barker found it to do. Yet on account of the greater labor and expense of making and using it, and of the greater difficulty of examining beneath it, the hanging tin band, described as used by Mr. Jones, is preferable.

Belts of cotton wool have been used to entangle the feet of the moths, and collars of tin plate, fastened around the trees and sloping downwards like an inverted funnel, have been proposed, upon the supposition that the moths would not be able to creep in an inverted position beneath the smooth and sloping surface.

[100] From a newspaper cutting.

CLASSIFICATION OF CONTRIVANCES AND PRECAUTIONS NECESSARY.

"Now, all these appliances, of whatsoever character, are divisible into two classes: First, those which prevent the ascension of the moth by entangling her feet, and trapping her fast, or by drowning her; and, second, those which accomplish the same end by preventing her from getting a foothold, and thus causing her repeatedly to fall to the ground until she becomes exhausted and dies.

"The remedies of the first class are thoroughly effectual when applied understandingly and persistently. And by this I mean, that the orchardist must know that many of the moths of *vernata* and most of those of *pometaria* issue in the fall of the year, and that the applications must, in consequence, be made at least as early as the latter part of October, and that they must be kept in effective condition, through all but freezing weather, till the leaves have well put out in the following spring, and that if, at any season, the parents or the worms are running in great numbers, they may bridge over the obstacles with their dead-bodies, over which the later individuals can pass, in which case a renewed application must be made. Furthermore, he must know that many of the moths—frustrated in their efforts to climb the tree—will deposit their eggs near the ground or anywhere below the application, and that the young worms hatching from them are able to pass behind the slightest crevice or over the finest straw. Thus, if troughs are used around the trunk, they must be fitted over a bandage of cotton wool, cloth, hay, or seaweed, so that when the trough is drawn tightly around the tree, it will do no injury, and at the same time all the inequalities of the bark will be filled up; "the joint must likewise be kept smeared either with tar or molasses, and then the worms will not be able to pass. In the neglect to thus fasten them, lies the secret of failure which many report who use such troughs.

"Contrivances of the second class are of no avail whatever, for although the moth is unable to travel over a very smooth surface, I know from experience that the young worms can march over the smoothest glass by aid of the glutinous silken thread which they are able to spin from the very moment they are born. For these reasons, even the 'Merritt's Patent Tree-Protector,' which was so well advertised by Mr. Howard in his otherwise excellent article on the Canker Worm, in the Michigan Agricultural Report for 1865, must be classed with the worthless patents. This 'Protector' consists of a ring of glass grooved below and hung from the tree by a tent of canvas, to which it is fastened by an iron clamp."

The first year that tar, ink, or any substance which kills the moth is used, there is constant danger that the moths will appear in such numbers as to "bridge over," and thus enable some to cross on the dead bodies of their comrades. But after an orchard has been well protected, there is little danger that the moths will next year go up in sufficient numbers to do this.

LE BARON'S TRAP.—Dr. William Le Baron found, in 1871, that by attaching a band of polished tin closely around the trunk of the tree, so that the female moths could not ascend the tree without crossing this band, the moths were to a large extent checked in their ascent, not from inability to cross the band, but from being baffled in their instincts. This preventive, however, was not thorough; but by fastening the tin band over a ring of rope with which the trunk of the tree was encircled, so that both the upper and lower edges of the band might stand out free from the trunk, the moths were completely baffled, and, if they reached the upper edge of the band, would not descend inside so as to reach the trunk again.

Mr. R. M. Milliken experimented with this tin and rope trap in 1873 on a small orchard of 39 trees, and gave the following, in the *Prairie Farmer*, as his experience:

In 1873 I applied the rope and tin in this way: I nailed a rope tight around the tree, took tin five inches wide and nailed it on the rope, half the tin above the rope and half below it. I put it on with three-penny nails. After I put the tin on, I took lime and sand and made a thin mortar and poured it in on the rope to stop any holes that might be left. When the tin gets full below, they will get on the tin, but won't go down above to get on the tree. I saw them on the tin (that is, the moth), but did not see one above it. I have known some to try it on a few trees, and condemn it because it was not successful. If the trees don't stand more than two rods apart the wind will carry plenty of the worms from one tree to another to strip it. My trees stand fully two rods apart, and in 1872 they were one complete mass of webs, made by the wind carrying the worms from one tree to another. My trees measure from two to four feet in circumference, and it did not cost me twelve cents for each tree.

"If the trunk is kept clean below the trap, and an application of kerosene made to the eggs from time to time, there will be no necessity for plastering the upper part of the trap. It is more difficult to check the ascent of the young worms than their parents, because of their minute size and power to travel over the smoothest surfaces. The best way to do it is by greasing the eggs and thus preventing their hatching. If the tin is smeared with a mixture of equal parts of kerosene and castor oil, it will prove still more effectual."

Dr. Le Baron says further:[101]

There is a period of about three weeks between the time of the laying and that of the hatching of the eggs, when the whole generation of the spring Canker Worms is safely ensconced under the scales of bark on the trunk and larger branches; no matter whether they are deposited in the fall, the winter, or the spring, they are all there now, and just to the extent that we can destroy these eggs we shall exterminate the Canker Worms. It follows, therefore, that if we scrape off the scales and burn them we shall prevent the hatching of a considerable proportion of the worms. Yet many will remain; probably the greater part of them will adhere to small scales, which our scraping will not remove. But by removing the larger scales the remainder will be more or less exposed, and the application of any wash that we may desire to make will be rendered easier and more efficacious. Having scraped off the larger scales, therefore, the next thing will be to apply some substance which will destroy the eggs without injuring the tree. Is any such substance known? We have applied soft

[101] Prairie Farmer, March, 1873 or 1874.

soap and a solution of Paris green to the eggs of the Canker Worm moth without destroying their vitality, but the least touch of kerosene oil is fatal to them. Can this substance be applied safely to the trunks and branches of trees? Some half dozen experiments performed by myself, and recorded in my second annual report, go to show that it can. Still, it is so powerful an article that we have never ventured to advise its use, indiscriminately. We need further experiments and on a larger scale. We would advise its use the first year on only a part of the trees, and those the least valuable. At any rate, the worms will destroy your trees in a few years, and a desperate disease sometimes requires a desperate remedy.

It may be asked whether some less powerful wash will not answer the purpose. None is known with certainty. We have heard of common lye from wood ashes being used effectually, but the statement was too indefinite to have much weight. If the lye were pretty strong, and especially if it could be applied hot, it appears to us that it would be as likely to prove effectual as any wash we can think of less potent than the kerosene. It would be interesting to experiment with lye of different degrees of strength; and if, as we have intimated, it could be served out hot from a large kettle set in the orchard, it would undoubtedly be more effectual, and would require the lye to be of less strength.

We have stated that this treatment must be limited to about three weeks in the year, being the time between the laying and the hatching of the eggs. The reader may ask how he can definitely determine this time. No fixed time can be stated in advance. It may vary nearly a month, according to season and latitude. The only way to determine it is to examine the trees from time to time, in the edge of the evening when the moths are most active, and observe when they have stopt running for the season; give a week longer to make sure that they have all gone up, and then scrape the trees and apply the wash between this time and the hatching of the eggs, which takes place about the time the apple leaves are beginning to expand, and the red currant to blossom.

JARRING AND BURNING.—"Vigilance is the price of reward, and as it is always easier to prevent than to cure, it were well for the owners of young orchards, in neighborhoods where the Canker Worm is known to exist, to keep a sharp lookout for it, so that upon its first appearance the evil may be nipped in the bud. In the same manner that it is exterminated in the individual orchard, in like manner, it may, by concert of action, be exterminated from any given locality.

"The worms should not be allowed to reach the leaves, but where they have thus been allowed it is best to strew the ground lightly with straw on a calm day, give the tree a good jarring, which will suspend all the worms in mid-air, cut loose the suspended worms by swinging a pole above them, which breaks their silken threads and causes them to fall to the ground, and then set fire to the straw. A Canker Worm holocaust will be the result and if this is done on a calm, clear day, with a little care the tree need not be injured. Even if the fire is not made, the worms may be prevented from returning to the tree by the same means which were employed to keep off the perfect females."

WASHES AND DUSTINGS.—It is said than some persons have saved their trees from these insects by freely dusting air-slacked lime over them while the leaves were wet with dew. Showering the trees with mixtures that are found useful to destroy other insects has been tried by a few, and although attended with a good deal of trouble and expense, it

may be worth our while to apply such remedies upon small and choice trees.

Dr. Harris tells us (p. 339)[102] that Mr. David Haggerston, of Watertown, Mass., has used for this purpose a mixture of water and oil-soap (an article to be procured from the manufactories where whale-oil is purified), in the porportion of one pound of the soap to seven gallons of water; and he states that this liquor, when thrown on the trees with a garden engine, will destroy the Canker Worm and many other insects without injuring the foliage or the fruit.

PARIS GREEN.—Mr. E. F. Curtis, of Rockford, Ill., described, in 1874, the successful use by him of Paris green in water, as had been suggested by Dr. Le Baron. He applied this mixture—a table-spoonful of Paris green to a dozen quarts of water—with a large syringe, to destroy the worms on the leaves. He says: "When the worms are all hatched, as near[ly] as can be judged, give the trees a good wetting down, and if afterward it is discovered that they were not all killed, put on more, but usually one wetting will answer. I know orchards that in 1872 were covered with this worm, the foliage and fruit crop completely destroyed, that were treated as above last year [1873] with perfect success—the worms killed, and the orchards produced fine crops of apples. This liquid will not only destroy the Canker Worm, but the myriads of insects that are to[o] small to be seen upon the foliage of the trees. One party says that after using it last year in his orchard the foliage made such a luxuriant growth and so dark a green that it was almost black.[103] It can be used just as safely in the flower-garden, destroying the insects that infest the shrubbery, as in the orchard."

MURIATE OF LIME.—"As for muriate of lime (*i. e.*, burnt oyster-shells and salt, to be strewn upon the ground), which has been so earnestly recommended as a preventive, by interested parties, here is what Mr. Sanford Howard says of it in the *Western Rural* of August 18, 1866, and Mr. Joseph Breck, editor of the old American *Journal of Horticulture;* G. C. Brackett, correspondent of the *Maine Farmer*, and several other persons with whom I am acquainted, all testify, after having thoroughly tried it, to its utter worthlessness for this purpose:

"The editor of the *Farmer* says, there are statements to the effect that a substance called Gould's muriate of lime, applied to the soil in autumn, had entirely prevented the subsequent appearance of Canker Worms on trees standing on the ground, although the trees had previously been much damaged by the insect. It is also stated that on other trees, not ten rods distant, where none of the so-called muriate of lime was applied, the worms were very destructive.

"I cannot think that this amounts to any proof that the substance applied destroyed the worms, or had any effect on them. The non-

[102] Report on Insects.

[103] This blackness was probably caused by the injury which the poison did to the leaves.]

appearance of the insect in the case alluded to, was probably due to other causes. If this substance will kill or injure the insect in any of its stages, it would be easy to prove it by a direct application to soil containing insects, in a box. Several years ago, I took pains to make a particular experiment with this so-called muriate of lime, the result of which was that the Canker Worm underwent its transformations naturally, and to all appearance healthfully, in a soil composed of nearly fifty per cent. of the articles of which it was said a small proportion only was necessary to totally destroy them. If the substance is the same in composition now that it was then, it is reasonable to suppose that the result of its application would be the same."

PLUGGING SULPHUR IN THE TREE.—The often repeated recommendation to bore holes in the trunk of the tree with an auger, fill the hole with sulphur, and close the orifice tightly with a plug, which originated, some years since, in the inventive brain of some *Prairie Farmer* correspondent, is altogether too absurd to need consideration; for it is well known to entomologists that many caterpillars will thrive exceedingly well on leaves that have been thickly sprinkled with sulphur, so that the impregnation of the leaves with the sulphur, if it took place, would be of no avail; and, moreover, it is also known that the sulphur thus introduced will remain unchanged and unabsorbed in the tree for years, having no effect upon the leaves whatever. The same may be said of the use of quicksilver in the same way. The practice of driving nails into the tree for the same purpose is equally absurd.

FALL PLOWING.—"A good deal has been said both for and against fall plowing, and the following discussion, which took place at the November (1868) meeting of the Alton (Ill.) Horticultural Society, will afford a sample of the different opinions held by individuals:

"Dr. Long took the ground that fall plowing was one of the best and surest means of eradicating those insects which stay in the ground over winter. He said, some five or six years ago my orchard was badly infested with the Canker Worm; by late cultivation, I almost, if not entirely, got rid of them.

"Dr. HULL. I do not believe that fall plowing will destroy the larvæ of insects to any extent. I have dug up frozen lumps containing larvæ that were not affected by freezing. I think the Canker Worm will not spread here as in New England.

"J. HUGGINS. I have been led to believe—contrary to Dr. Hull's statement—that they will spread, and feel that there is great danger of their spreading. I believe fall plowing a great aid in the extermination of them. Cites a case where they have been almost entirely destroyed by late plowing, in an orchard that was nearly ruined by them.

"Dr. HULL. If it be true that they will spread, why is it that none of Dr. Long's neighbors have them? He says he was badly overrun with them, and the fact that his neighbors were not, I think confirmation of my statement that they will not spread.

"Dr. LONG. My brother's orchard, adjoining mine, had double as many as my own. He fall plowed, and has very few left. He also cites the case of an old orchard, in this section, that was almost destroyed by them, but fall plowing has almost, if not entirely, destroyed them."

The following item, from the New York *Weekly Tribune* of February 26, 1869, also bears on this point:

CANKER WORMS DESTROYED BY PLOWING.—Mr. McNeil Witherton, in answer to W. V. Monroe's request: "I will state that I think that the Canker Worm can be destroyed by plowing the ground where they are late in the fall. The 28th of November, 1867, I was at my son David's, in Wisconsin. He told me that the Canker Worms were in his orchard, and had injured his apple trees very much the past season; that a man who owns a nursery and keeps apple trees for sale, went into the orchard and examined the trees and worms, and said it was the Canker Worm that was injuring his orchard. I told him that about fifty years ago they had been in my father's orchard some six years, and killed a large number of the trees; that we plowed it late in the fall, and have never seen the Canker Worm there since. I advised him to plow his orchard immediately. The next day he plowed it as far as the worms had been in it. I received a letter from him a few weeks ago, stating that the Canker Worms were not in his orchard this year, and those trees that were injured and not killed last year revived some this year."

Mr. Cyrus Thomas reprints, in the Sixth Illinois Report, 1876, p. 21, an extract from the *Western Rural*, in which the writer states that in the last of June, after the worms had left the trees and burrowed in the ground, he plowed or summer fallowed one of his orchards which had been eaten; he afterwards cross-plowed it and sowed it with rye. The next year he caught no moths in this orchard, the foliage was not eaten at all, and he had a good crop of apples on it, while all of his other orchards, though tarred, were badly eaten, and he had no crop of apples on them.

"Now there is no doubt but late fall plowing will produce somewhat different effects, according to the character of the soil, the depth of the plowing, and especially the species of the insect to be dealt with, but that it is more generally beneficial than otherwise as a means against the spring species I am perfectly convinced, and as for the assertion of Mr. William P. Lippincott, of Vernon, Iowa, made some time ago, in the *Iowa Homestead*, namely, that it left the ground full of harbors for the next year's breeding, it suffices to say that the insect does not breed in the ground, and, holes or no holes, the worms will penetrate the soil whenever the time arrives to change to chrysalis. After the summer months the insect invariably lies in the chrysalis state snugly entombed in a little earthen cell very thinly lined with silk, from two to six inches below the surface. This cell, though frail, is a sufficient protection, so long as it is whole, from any excess of moisture, and at the same time prevents too much evaporation in case of summer drought or dry winter freezing. Here the distinction between the two species, in the manner in which the cocoon is constructed, is particularly important, from the practical standpoint.

"The Spring Canker Worm, with its chrysalis formed in a simple earthen cavity, will be very materially affected by late fall plowing of the soil, especially if the soil be of such nature as to crumble easily; for I have proved by experiment that whenever this fragile cocoon is disturbed or broken open in cold weather, as it very readily is by disturbance of the soil, at that season the chrysalis has not the power to penetrate the ground again or to form a second cavity, and in the great majority of instances either rots, dries out, becomes moldy, or, if on the surface, is destroyed by birds.

"Even summer plowing, if performed after the first of July would work beneficially; and it is for this reason, that clean, well-cultivated orchards are more free from the attacks of this insect, than slovenly and neglected ones. The only advantage of late fall plowing, lies in the facts, that the chrysalis is at that time too benumbed to work itself into the ground and form another cell, and that birds are then harder pushed for food, and more watchful for any such dainty *morceau*.

"As to the efficiency of hogs, in rooting up and devouring the chrysalids, during the summer months, abundant favorable testimony might be cited; but the facts are too obvious to need argument.

"With the Fall Canker Worm, on the contrary, these measures will avail little, if anything; for the cocoon, composed of a thick layer of yielding silk strengthened by the interweaving of particles of earth, cannot be broken open by any such processes, and a dozen plowings would not expose a single chrysalis. Without doubt we have in these facts a valid explanation of the contradictory experience as to the value of fall plowing or the use of hogs in an orchard as canker-worm checks.

"That the breaking open of the chrysalis of the Fall species would be equally injurious to that species seems to be shown by the result of experiments which I made in 1875, in trying to raise the perfect insects from cocoons which I had cut open in order to examine the chrysalids. From 58 chrysalids, two of which were males and the rest females, I obtained only 2 male and 25 female imagos; the remainder all perished by rot, induced doubtless by this premature opening of the cocoons."

Dr. Harris says[104] that Mr. S. P. Fowler and Mr. John Kenrick, of Newton, Mass., advise us to remove the soil to the distance of four or five feet from the trunk of the trees, and to the depth of six inches, to cart it away, and replace it with an equal quantity of compost or rich earth. In this way many of the insects will be removed also; but unless the earth thus carried away is thrown into some pond-hole, and left covered with water, many of the insects contained in it will undergo their transformations and come out alive next year.

ENCOURAGEMENT OF BIRDS—BREEDING OF PARASITES.

It is well known that in Philadelphia, as in many other eastern cities, the Canker Worm was formerly a great nuisance, not only because of the

[104] Report on Insects of Massachusetts, pp. 339–340.

injury it did to the elms and other shade trees, but because it was continually spinning down on persons who happened to be passing underneath the infested trees.

PRACTICAL CONSIDERATIONS THAT RESULT FROM THE DIFFERENCES IN THE TWO SPECIES.—The illustration of the differences between the two species of Canker Worms may seem unimportant and trivial to the horticulturist, however much they may interest the entomologist. Yet it is of much practical importance to know how to make the distinction. From present knowledge of the subject, it is highly probable that, just as the moths of the one species appear mostly in early spring, and of the other mostly late in the fall, so each is, in a general sense, confined to particular plants (though not exclusively so), the Spring species preferring our fruit trees, and the Fall species preferring the elm. Thus the time to put forth our efforts to catch and destroy the wingless moths will vary according to the nature of the tree to be protected and the insect to be dealt with.

"In the case of the Spring species, the eggs being secreted, for the most part, under loose bark, the scraping of the tree and otherwise cleansing it of dead leaves, cocoons, larva-cases, &c., a short time before the hatching of the worms, or before the buds of the tree commence to open, will prove an effectual preventive measure; as thereby many of the eggs will be destroyed. Moreover, a tree kept clean of loose bark will be less subject to its attacks. The same argument will not apply to the Fall species, which attaches its eggs in any exposed position. It would seem, also, that the mode of trapping the moths will have to be somewhat modified, according to the species to be dealt with; for while Dr. LeBaron found the tin and rope trap described above so effectual with the Spring Canker Worm, it does not appear to afford a complete barrier to the Fall species, judging from the following notes, kindly furnished by Mr. Mann. It will be noticed that Mr. Mann used zinc instead of tin, from its less liability to rust.

Nov. 8, 1873. Warm last night, with rain, which still continues. Found 25 ♀ and one ♂ *pometaria*. Found 4 of the ♀ above the LeBaron zinc band.

Nov. 9. Found 2 ♂, 37 ♀ *pometaria;* 2 ♀ above the zinc band.

Nov. 12. Snow last night, followed by cold sleet. Found 9 ♀ *pometaria,* 1 above the zinc.

Nov. 15. Only 6 ♀ *pometaria;* none above the band. Last three days freezing cold, but not stormy.

Nov. 18. Several days of rain and snow. 1 ♀ *pometaria.*

Nov. 22. 6 ♀, 2 ♂ *pometaria.*

Dec. 4. Yesterday thawing; to-day also. The weather since Nov. 22 has been cold, with occasional snow, and the ground has been frozen, and I have failed to find any *Anisopteryx pometaria;* but to-day I caught 11 ♂, 102 ♀, 2 ♀ above the zinc band. I have no doubt that the smallness of the number of ♀ found above the bands of zinc is due to my promptness and diligence in detecting and destroying them before they have had time to mount the tree; because, according to the theory on which the experiment was tried, the ♀ ought to be found on the outside of the strips, if their ascent has been prevented by them; while in fact (excluding those found on the house or fence, &c.), the majority of the ♀ have been caught before they reached the bands; further, be-

cause I tried the experiment with 3 or 4 ♀, and found that as soon as they reached the top of the band, they climbed over it, and began to ascend the tree. Being satisfied by this positive evidence, which would outweigh any amount of negative evidence from those who have *not seen it*, I put printers' ink on the outside of the zinc strips. (I found that the ink was more quickly chilled or dried by being on the zinc, so last winter I pulled it off and inked paper bands applied closely to the trunk.)

Dec. 5. Colder, 25 ♂, 71 ♀ *pometaria*. The greater proportion of the ♂ than formerly is explained by considering that most of them were stuck to the ink, whereas formerly they could hide away by day. It is to be noticed that although some imagos appeared before the frost, they only swarm after it, justifying the farmers' saying that you must have a frost to bring the canker-grubs out.

"In brief, all the more important measures to be pursued in our warfare against the Spring Canker Worm—such as the use of hindrances to the ascensions of the moths in spring; the removal of all loose bark, and keeping the trunk and limbs as smooth and clean as possible; the employment of hogs, and fall plowing—are, in the main, useless as directed against the Fall Canker Worm, which must be fought principally by traps or barriers *applied to the tree in the fall* to prevent the climbing of the moths, which mostly issue at that season. Important points like these cannot be too often insisted on, because I find that our horticultural writers yet very generally speak of THE Canker Worm as though there were only one species in the country, and give general directions which of course are more or less misleading. I find, too, that even where the differences pointed out have been recognized, they have not always been properly apprehended, as has been shown; so that in the report of a lecture before the Iowa Agricultural College it is erroneously stated that the eggs of the Fall Canker Worm hatch in the fall of the year, whereas, while the moths rise and lay their eggs at that season, these eggs do not hatch any earlier than do those of the Spring species."

The undeniable difficulties in coping with these insects, arising from a natural disinclination of men to fix their attention and perseverance so long upon one object, although the means are so simple, have discouraged many orchardists; and the editor of the *New England Farmer*, in answer to a correspondent, advises the felling and burning of all infested trees from one end of the State to the other, by virtue of a special law to be passed for that purpose, "even if it takes all summer and *every militia man in the State* to execute the order."

Mr. B. D. Walsh, in commenting on this advice[m] says:—"Instead of advising the Michigan legislature to pass a law for cutting down and destroying all trees infested by the Canker Worm, why not advise them to pass a law compelling the owners of infested trees to tar them as above specified? Or, better still, because more certain to be effectual, to pass a law organizing a paid corps of men in the infested districts to do the work? *There would then be no occasion to call out the militia.* A man might shoulder his rifle, if he saw the sheriff and his posse coming, ax in hand, to cut down his orchard; but he would only laugh when he saw them charging, double-quick, upon his apple-trees, with presented tar-brushes."

---

[m] Pract. Entom., v. 2, p. 16-17.

CHAPTER VIII.

THE HESSIAN FLY—ITS RAVAGES, HABITS, AND THE MEANS OF PREVENTING ITS INCREASE.[106]

INTRODUCTION.

Next to the Rocky Mountain Locust, the Cotton Worm, and Chinch Bug, the Hessian Fly is at present the most destructive of our noxious insects. It attacks wheat, our most important agricultural product, and at times has been so abundant as to cause farmers to abandon the culture of this grain over large sections of the Union. While the fly has been well known and destructive for about a century, the vast extension within a decade of years of the wheat-growing area of the West, and the corresponding prevalence of the fly in the Northern Central States, together with its wide-spread destructiveness, have given fresh interest and importance to this pest. Moreover, the cultivation of wheat in the New England States, where about twenty years ago it was abandoned on account of the ravages of this fly and the Wheat Midge, has been resumed in part, so that the dissemination over the wheat area of the United States of the known facts in regard to its habits and mode of doing injury seems necessary. This area, as seen in part by the map[107] appended to this chapter, which has been compiled from Walker's Statistical Atlas, embraces all of the United States north of the 35th parallel of latitude and east of the 93d meridian, with the addition of tracts in Dakota, Montana, Colorado, New Mexico, and Utah, as well as in California, Oregon, and Washington Territory. These last-named wheat areas were not mapped by General Walker, and have been omitted on the present map, since the Hessian Fly is not known to exist west of eastern Kansas.

Though the habits of the Hessian Fly are tolerably well known, much additional knowledge is desirable regarding its distribution, its breeding habits, and its parasites, while, in order to properly apply the best preventive remedies, to stamp out the pest as it appears in new wheat sections, we need the results of a larger number of experiments as to the effects of early and late sowing, what varieties of wheat to sow, and as to the value of manures and artificial fertilizers in promoting the rapid and healthy growth of the young wheat, by which it may outgrow the weakening effects of the worm and ripen its grain.

[106] Reprinted, with some alterations and additions, from Bulletin No. 4 of the U. S. Entomological Commission.

[107] This map is based on the one which appeared in Bulletin No. 7, but with corrections and additions.

Although this chapter has been prepared by but one member of the Commission, the writer is indebted to Prof. C. V. Riley for drawings, specimens, and data; to Professor Thomas for facts and suggestions; and he would also acknowledge aid received from Prof. A. J. Cook, of the State Agricultural College, Lansing, Mich., whose address on the Hessian Fly has been of much service and liberally quoted, and also from the correspondents and agricultural papers mentioned here and there in the following pages.

LOSSES OCCASIONED BY THE HESSIAN FLY.

This fly first became a serious pest in the country in the year 1779, although, as will be seen further on in the section on the distribution of the insect, it probably began its work of destruction on Staten Island and Long Island in 1776. According to Fitch, 1779 was probably the date when its ravages actually began. "The crops of wheat were severely injured or wholly destroyed by it in King and Richmond Counties during several of the following years, and each succeeding generation regularly enlarged the sphere of its devastations in every direction."

In 1781 the fly almost totally destroyed the wheat crop in eastern Long Island, and in 1786 the crops were either totally or partially destroyed in New Jersey in and about Prospect, an area situated forty miles southwest of Staten Island. In 1786 and 1787 the ravages of this pest attracted much attention in New York and Pennsylvania; the wheat crop on eastern Long Island having been "cut off almost universally." About Trenton, N. J., in 1788, the wheat crop was in many cases a total failure. As wheat in large quantities was at this period exported to Great Britain, "accounts of the appalling havoc that this insect was making excited the attention of the government there and aroused their fears lest so dreadful a scourge should be introduced into that country by means of the American grain." (Fitch.) As a result, the exportation of grain from America was prohibited until the English Government was assured that the fly with eggs could not be introduced in the grain. As long since as 1800, Dr. S. L. Mitchell, of New York, affirmed that "the insect is more formidable to us than would be an army of twenty thousand Hessians." (Herrick.)

Between 1789 and 1803 severe losses ensued from its attacks in Saratoga and Washington Counties, New York; "on two or three occasions many of the fields in Saratoga were entirely destroyed."

In 1804 President Dwight, of Yale College, remarked that "this insect is feeble and helpless in the extreme, defenseless against the least enemy, and crushed by the most delicate touch; yet for many years it has taxed this country annually more, perhaps, than a million of dollars." (Herrick.)

In 1803 and 1804, in the neighborhood of Richmond, Va., "they swept whole fields." In 1817 it "renewed its ravages in various sections of

the country; was unusually abundant," and "in parts of Maryland and Virginia it was perhaps more destructive than it had ever been before."

At what year the Hessian Fly first occurred in the New England States is uncertain; so far as we can ascertain it was first noticed at New Haven, Conn., in 1833, by Mr. Herrick, a careful entomologist, but without doubt it was introduced from New York early in the century.

In Lower Canada it was, according to Hind,[108] between 1805 and 1816, "prevalent and destructive in some parts," but in 1830–'36 it disappeared in Lower Canada.

The fly first appeared in 1837 at Paw Paw, Mich., in the second crop sown in Van Buren County; none had been raised at a point nearer than twelve miles. (D. Woodman.)

The Hessian Fly has been known in Person County, North Carolina, for fifty years; and another correspondent writes us from Goldsborough, N. C., that—

> Previous to the period, say 1840, our farmers had been accustomed to sow wheat as early as September, but a fly, called by them the "Hessian Fly," so depredated that they deferred sowing to the latter part of November, and now, generally, to "between the Christmases" (new and old Christmas); their crop is now unmolested by the Hessian or any other fly.

The losses in Pennsylvania in 1842 were heavy, the wheat crop of the State being estimated at 20 per cent. less than in the preceding year, the fly being the principal cause of the loss. At this year Ohio was visited by it, when "it appeared to be increasing so much that serious apprehensions were beginning to be felt respecting its future ravages." (Fitch.)

Great havoc in many fields in Maryland and Virginia was committed by it in 1843. In the following year it did much injury in northern Indiana and Illinois and the contiguous parts of Michigan and Wisconsin, in many places occasioning "almost a total failure of the crops." In Michigan the wheat crop was almost an entire failure. On Long Island, at Rochester, N. Y., and throughout Pennsylvania the losses this year were severe; the following year it did more or less injury all over the State of Illinois, while in the central parts of Maryland the crops, in many instances, were rendered totally worthless. "In Georgia, moreover, its ravages in the counties around Milledgeville are said to have been dreadful; whole fields were totally destroyed, and others yielded not more than a fourth of an ordinary crop."

In 1846, in the upper counties of Georgia, it was said "the fly has committed such ravages upon the wheat as scarcely to leave enough seed for another year." Throughout the State of New York it was destructive this year; in the western section the loss from this insect was estimated at not less than 500,000 bushels. In Maryland this same year (1846), as recorded by Fitch, "so great ravages have not been committed by the Hessian Fly since 1817. On some of the best land wheat has

[108] Essay on Insects and Diseases injurious to the Wheat Crops, by H. Y. Hind, Toronto, Canada, 1857, 8°, p. 139.

been plowed up, and other portions are so much injured that they will not be worth harvesting. At least one-half of the crop of Talbot County has been destroyed." And in the upper counties of Georgia it is said "the fly has committed such ravages upon the wheat as scarcely to leave enough seed for another year."

In 1847 the losses were generally widespread but light, while in 1849 it was destructive in some of the counties in New York, and especially in Ohio. From this date until 1853 it was not destructive, but this year it "committed great ravages in some parts of Pennsylvania." In 1854 it was destructive in Aroostook County, Maine, as well as in Michigan.

From 1855 to 1860 the Hessian Fly attracted little attention from the agricultural community. In 1860 the fly "had reached as far west as Iowa and Minnesota, and in 1863 the wheat-fields along the Detroit and Milwaukee Railroad promised nothing because of the ravages of this pest." (Professor Cook.)[109] In 1866 it is reported to have occurred in Maryland, Delaware, and Ohio, and in 1868, according to a writer in the *American Entomologist*, about Fond du Lac, Wis., "much of the wheat crop was damaged by it."

In 1871 it was generally prevalent throughout the Middle States from South and North Carolina and Virginia to Missouri northward; also occurring in Kansas, Georgia, and Minnesota, and in 1872 and 1873 was destructive and widespread in Maryland, Ohio, Indiana, Illinois, and eastern as well as western Virginia, as well as in Michigan, "as also in the States south and west" of the last-named commonwealth.

In 1874 it was widespread, but much less destructive; in 1875 and 1876 it was especially destructive in Missouri, Pennsylvania, and Virginia. In 1876 "it appeared in force in many of the southern counties of Michigan, reaching as far north as Mason, in Ingham County, causing much destruction." (Professor Cook.)

In 1877 the losses again became heavy over a large part of the wheat area. At Lawrence, Kans., the early-sown wheat "suffered a good deal from the ravages of the Hessian Fly." At Gardner, Kans., all early-sown wheat "was full" of the "flaxseed" of the Hessian Fly. At Saint Genevieve, Mo., the fly was "much worse than for years past." At Independence, Mo., the crop in some fields was nearly a failure. In Henderson County, Kentucky, while prevalent, only one wheat-field was "badly damaged"; while in Vanderburgh County, Indiana, "many fields were infected." In central Illinois a correspondent of the *Cultivator and Country Gentleman* states that "the Hessian Fly has been present in the lower portion of the winter-wheat region for several years," and in 1877 "it appears that the Hessian Fly is generally present in greater or less numbers over the whole winter-wheat region; that in almost every case it has attacked and done more or less damage to early-sown wheat-fields."

[109] In his seventh report, written apparently in 1862, Dr. Fitch remarks: "We hear of it at the present time as very destructive in Illinois and some of the contiguous States, the crop in many wheat-fields being totally ruined by it."

In Michigan the fly, while troublesome in 1876, was also very generally so in the succeeding year, as stated by Professor Cook, as follows:

This year, 1877, we hear of it as more broadly distributed in our State, while complaints come to our ears from Ohio, Indiana, Illinois, New York, and Pennsylvania. Since writing the above, I have passed through our State and also the State of Ohio, on two of the different trunk lines of railroads, and I find that all through southern Michigan and all of Ohio, at least north of the latitude of Columbus and Dayton, this insect abounds in force.[110]

The following extracts from Michigan papers show the situation in that State this year:

Farmers are complaining of the ravages of the "fly" in their wheat-fields. Much damage is reported.—*Jonesville Independent.*

Mr. James Taylor showed some wheat-stalks from his farm to-day which had over forty insects in one stalk.—*Kalamazoo Gazette.*

Wheat heading out ten days to two weeks earlier than usual this year, and doubtless much of it will be ready to cut in June.—*Portland Observer.*

The "fly" or "insect," as called by the farmers, is playing sad havoc with the wheat crop in this county. Not over half a crop will be realized.—*Kalamazoo Gazette.*

The fly is very seriously injuring the wheat in Porter. One of the largest farmers in that township yesterday told us that a few weeks ago he would not have taken 3,000 bushels for his crop, but now he would gladly take 1,000.—*Paw Paw Courier.*

Much complaint is now heard from all sides in regard to the work of the insects in early-sown wheat. The dry weather has so far retarded the growth as to give the pests the power to destroy. There is little question that early-sown wheat is suffering greatly.—*Marshall Expounder.*

Farmers from all over the county come to town looking doleful enough. The wheat crop promises to be almost a total failure. Two weeks ago everybody was happy over the prospects of an abundant harvest, but now flies, worms, and drought seem to have ruined the crop and blighted every home.—*Marshall Statesman.*

Farmers from all the adjoining towns complain that their growing wheat crops are badly injured by the insects. Wheat-fields which promised a heavy yield two weeks ago, it is thought, will not produce over a half a crop, and many fields are reported as already nearly destroyed. Naturally some allowance should be made for the apprehensions of those whose fields are thus ravaged; but there is no doubt that the crop through this section is materially damaged by these destructive pests.—*Battle Creek Journal.*

Mr. T. F. Miller, of Richland, brought into our office Monday morning a handful of wheat (taken from a farm on the prairie) that is literally alive with the insect. He says that in his opinion nearly every field in Richland is so badly affected that there cannot be half or even a third of a crop. The dry weather has stopped the growth, and the wheat is more affected on that account. We hear the same report from other parts of the county. Grain is also suffering for want of rain.—*Kalamazoo Gazette.*

The following extract from the Albany *Cultivator and Country Gentleman* will give the condition of affairs in West Virginia:

Since reading your article making known Mr. A. S. Packard's request, in the issue of November 15, I have had occasion to make a business trip through Hardy, Hampshire, Mineral, and Grant Counties, and find upon examination that there is not a single field which is not more or less damaged by the fly. The early-sown wheat, having luxuriant growth, does not seem to be entirely destroyed, but has the appearance of mixed yellow and green. I find, upon close examination, it is filled with the fly.

[110] The Hessian Fly. A lecture by Prof. A. J. Cook, of the Michigan State Agricultural College, delivered at Farmer's Institute held at Paw Paw and Climax, Mich. 1878, 8vo., p. 14.

Other fields, sown after corn-cutting, show a greater amount of damage; one in particular, a limestone upland, was scarcely tinted with green, the fly having already consumed nearly the whole of it. My course from this point was north and west. I find that the farther north I travel the more damaged is the wheat. In this (Hardy) county the damage, so far, appears not to be material. Some crops of early-sown wheat were considerably shortened last year, the first year in many that we have felt the effects of the fly. One farmer, whose wheat seemed already a failure, asked me what he should do. I advised when the land was dry, or hard frozen, to put all the sheep he could get upon it, and keep them there until they had eaten it off as close as a sheep could nip, as the only remedy. I thought that the sheep could do no worse than what must be eventually done by the fly, and it might save the crop. He asked me if I thought the insect would be "wholesome for the sheep." This I could not answer, and refer the query to you.—R. M. W., Moorfield, W. Va.

A correspondent of the same paper thus records the injury done by this insect about Syracuse, N. Y.:

Wheat sown early, from the 1st to the 20th of September, has made an extraordinary growth. The fine weather was favorable; besides more care has been paid to good culture than before. The seed also has been selected, cleaned, and graded with greater care, showing much progress. From apperances now, it will result in a loss. Whole fields, and parts of others, are turning yellow, showing the ravages of the fly to a larger extent than I ever before witnessed. It began to turn yellow on knolls, or where the plaster rock came near the surface, and was thought only the effect of dry weather, but now it has extended all over early-sown fields. Should the warm weather continue, great injury will result to the entire crop, as it has been sown much earlier than usual and has looked remarkably fair. Later sowing, with a gr ater breadth of spring wheat, is the only remedy now offered. Will other parties in different sections make an examination and send notes?—C., Syracuse, N. Y.

While, so far as we have been able to learn, no serious damage, if any, has been done to wheat in New England by this pest since 1854, in western Canada it again became abundant in 1874, but most injurious in 1876 and 1877. In 1876 it appeared in great force in the townships of Anabel, North Bruce, Grey, and Kippel.

In 1878, the losses were still heavy in southern and central Michigan, but in 1879 the insect seemed to be moving northward, the greatest amount of injury being sustained in the northern part of the State, the fly being scarce in the middle of the State.

As regards its abundance in southeastern Michigan in 1878 and 1879, Mr. F. S. Sleeper, of Galesburg, near Kalamazoo, writes me as follows:

In February, 1878, I noticed what was to me something new. The month was very warm and spring-like. For nearly three weeks the temperature did not reach the freezing point. About the middle of the month I noticed many flies flying over the wheat and depositing their eggs, but, so far as I could see, none reached the "flax-seed" state. I have several times noticed the fly depositing her eggs as late in the autumn as October 26.

Since the summer of 1877 no very serious damage was done until last spring (1879). Then the fly put in an appearance. On the 26th of May, above one field of wheat the air was almost black with them. I never saw such a sight before. I had fears that the fall-sown wheat would be badly damaged, but it is not so, as none but early-sown wheat is damaged in the least. I presume it is owing to the fact that September was cold, so that probably the sudden atmospheric changes destroyed all that had not reached the pupa state.

In 1878 it did great damage in Dickson County, Tennessee. In Maryland, the winter wheat in the neighborhood of Baltimore, Md., was, in 1879 and the spring of 1880, seriously affected. In central New York, in Seneca and Tompkins Counties, considerable damage was done in 1878 and 1879. About Watertown, N. Y., some injury was done in 1879, one field of wheat being ruined.

In 1879 apprehensions that injury would be caused by the fly were felt in Lowell, N. C.

More or less damage was done to winter wheat in the fall of 1879 in the following localities: Northampton County, Pennsylvania; Baltimore and Frederick, Maryland; Prince William, Green, Culpeper, Orange, King William, Craig, Rockingham, and Amelia, Virginia; Henry and Davidson, Tennessee; Morgan, Pleasants, Putnam, Wetzel, and Mason, West Virginia; Bourbon, Carroll, Fayette, Lyon, McCracken, McLean, Nicholas, Russel, Scott, Shelby, Fleming, Jessamine, Jefferson, and Mason, Kentucky; Adams, Meigs, Portage, Union, Vinton, Mercer, and Scioto, Ohio; Gratiot, Michigan; Decatur and Switzerland, Indiana; Coles, Johnson, Livingston, Lawrence, Moultrie, Perry, and Union, Illinois; Davis and Lee, Iowa; Crawford, Washington, Perry, Sullivan, Gasconade, Lincoln, and Saint Charles, Missouri; and Doniphan County, Kansas.

In 1880 all of the South Atlantic States suffered to a greater or less extent, and the following localities are definitely mentioned in the crop reports of that year: Brooks and Jackson Counties, Georgia; Collin, Texas; Ballinger, Missouri; Nicholas, Kentucky; Pike, Ohio; Berry and Saint Clair, Michigan; Marshall, Indiana; Dodge and Door, Wisconsin.

According to Professor Riley, in 1881 it was prevalent in Illinois and Missouri:

In many parts of central and southern Illinois and in Missouri this insect has been reported as doing considerable damage, many farmers having to plow up their winter wheat in consequence. Mr. Thomas H. B. Moulder, of Cane Pump, Camden County, Missouri, sent the insect in the flax-seed state, the latter part of June, with the statement that he had forty acres of wheat which all fell or broke down about two weeks before ripening, from the insect's injuries. The western agricultural papers have had abundant notices of the Hessian Fly this season, but as our eastern entomologists, as a rule, do not see those journals, it is more than probable that this year would be put down by them as one in which the species was not heard of or known. The present year is, however, not exceptional, and more or less injury has been done by this insect in the West every year since we have given any attention to entomology.—C. V. Riley, in *American Naturalist*, September, 1881, p. 750.

The counties reporting injury by the Hessian fly in 1881 are as follows: Tioga, New York; Hunterdon, New Jersey; Bucks, Cumberland, Lebanon, Columbia, Northumberland, Pennsylvania; Anderson, and Sumner, Tennessee; Harrison and Park, Indiana; Edwards, Wabash, Lawrence, Fulton, Madison, Christian, Effingham, Clark, Edgar, Cumberland, Gallatin, Jasper and Shelby, Illinois; Knox, Morrow, Allen and Auglaize, Ohio; Lawrence, Madison, and Perry, Missouri.

The following complete account of the appearances in 1882 is from Special Report No. 42 of the United States Agricultural Department (published April, 1882):

In a large portion of the wheat area there has been absolute freedom from the presence of this pest of former times. It has been reported far more frequently in the eastern portion of the Ohio Valley than in the western and beyond the Mississippi. A few districts on the Atlantic coast have suffered from its visitations; the area sown in August and very early in September receiving its exclusive attention. A careful analysis of the extent of local injuries is given in the following paragraphs:

No injury is reported in New England, except a little in Litchfield County, Connecticut, confined to sandy ground. In Wyoming County, New York, fields commenced to turn yellow in spots early in the fall, and the loss from the insect is estimated at 10 per cent. Very slight damage is reported in Genesee, Ontario, Niagara, Columbia, Yates, Monroe, and Herkimer. Scarcely appreciable loss is indicated in a few districts in New Jersey, mainly in Salem, Warren, Mercer, and Camden.

Pennsylvania has been comparatively exempt from insect injury. In Huntingdon, a loss of 20 per cent. is reported; in Lancaster, one-sixth, from too early seeding. On some farms in Franklin large losses occurred. Very slight injury is reported in Lawrence. Westmoreland, Susquehanna, Clinton, Franklin, Bradford, and Dauphin are among the counties where the presence of the fly has been observed, though the damage is small.

Maryland wheat has suffered very slight loss by the fly, in most cases scarcely worth mentioning. It is avoided by late seeding.

In Wisconsin the loss is estimated at 10 per cent. Considerable injury was caused in Dorchester by a worm one-fourth inch long working under ground.

In Virginia, the only counties mentioning the appearance of the pest are Caroline, Westmoreland, Greenville, King and Queen, and Fairfax; in no instance amounting to an appreciable infliction. A large number of North Carolina counties are declared exempt, Chatham, Montgomery, and Yancey being the only exceptions. In Fairfield County, South Carolina, a few fields were damaged 25 per cent. Elsewhere the insect was scarcely known.

Greater losses occurred farther south in the early planted areas, especially in Georgia. The loss in Worth County is assumed to be 30 per cent.; in Quitman, 25; in Talbot and Meriwether, 10; in Putnam, 5. The appearance of the fly is also noted in Walker, Wilkes, Randolph, Marion, Dawson, Crawford, Campbell, Bibb, Heard, Polk, McDuffie, Clark, and Catoosa. Alabama has been comparatively exempt; though in parts of Randolph County the injury was severe. In Saint Clair the loss amounted to 10 per cent.; and slight damage occurred in Lee, Mar-

ion, Franklin, and Etowah. In the southwest little complaint has been made of insect depredations of any kind. The fly is mentioned in Clay, Delta, and Rockwell. The army worm injured early wheat in several counties. A mention of the fly in early wheat fields is made in correspondence from Carroll, Howard, Newton, Scott, and Sevier, in Arkansas.

Tennessee reports slight injury from Anderson, Hancock, Knox, Stewart, and Union. Doddridge, Jackson, Jefferson, Nicholas, Pleasants, Ritchie, and Upshur are the only counties in West Virginia in which the insect has made an appearance to any noticeable extent; while no injury of a character at all serious is reported in Kentucky. The fly is mentioned in Graves, Hancock, Hardin, Harlan, Marion, Marshall, Muhlenburgh, Todd, and Trigg.

In Ohio our Hancock correspondent reports 50 per cent. of the early wheat eaten by the fly. The damage in Logan was greater than for many years, estimated at 15 per cent. for the crop. Some fields "two-thirds destroyed" is the report from Allen. From 1st to 15th of September whole fields of early sown were destroyed in Henry, with loss of 10 per cent. Most of that sown before September 15th in Clarke is injured; 50 per cent. of early sown eaten in Hancock; "badly damaged" in some localities in Knox; in Carroll and Seneca 8 to 10 per cent. of early sowing, later seeding untouched; badly damaged by the fly in Champaign; injured 15 per cent. in Marion; in Auglaize at least 33 per cent.; high, rolling, and thin land, nearly all destroyed; in Union all sown before September 23 badly damaged; all sown before September 20 injured in Erie; at least 25 per cent. of injury in Wyandot, and 40 per cent. in Van Wert. Some loss is reported in several other counties.

Very few indications of the fly were apparent in Michigan. Oakland County reported a loss of 10 per cent. and Ottawa of 5 per cent.

Half of the counties of Indiana mention the presence of the insect; in most the damage is not material; in a few it amounts to 5 or ten per cent. In Wayne it is estimated at 50 per cent.; in Lagrange, 40; in Adams and Pulaski, 20; in Jay there are some fields badly injured; in Carroll and Bartholomew the early sown suffered considerably.

Illinois is represented to be substantially exempt from injuries by the fly. "None" and "very little" are almost universal answers to the inquiry. Coles County estimates a damage of 5 per cent., and a few others still less. Missouri and Kansas have been equally free from its visitation.

In this year also it was reported by Mr. William Saunders to have been generally destructive in the Province of Ontario, Canada.

A meeting of the Ontario Entomological Society was held recently in Montreal, during the session of the A. A. A. S. After the transaction of the routine business, the president, Mr. William Saunders, of London, Ontario, delivered his annual address, in which he referred to the general prevalence of the Hessian Fly in the Province of Ontario during the past season, inflicting a loss on the agricultural com-

munity estimated at several hundred thousand dollars, and called attention also to the relative abundance of parasites among the insects now maturing.—*American Naturalist*, December, 1882.

These facts indicate that the losses from the Hessian Fly are greatest in the grain-raising areas of the Central States, and adjoining regions of Canada, and that the New England States have been comparatively free from their attacks, though this is perhaps mainly due to the fact that so little wheat is cultivated there. No statistics as to the losses have been collected until of late, either by the State or national governments, but they have been sufficient to occasion much consternation and alarm at certain years. By reference to the chapter on the supposed periodicity in its attacks or years of maximum abundance, the reader may learn approximately by the history of the past how often its more serious attacks may be probably renewed.

DESCRIPTION OF THE HESSIAN FLY.

This insect belongs to the Diptera or two-winged insects, of which the common house-fly is the best-known type. It belongs to the family *Cecidomyidæ*, a large group of minute flies, resembling the crane flies or daddy-long-legs (*Tipulidæ*), but of diminutive form. They are nearly all gall-flies, the females laying their eggs by means of the soft extensible end of the body which slides back and forth like the joints of a telescope. The irritation caused by the egg results in the swelling of the stems of plants, or the formation of tumors or galls on the leaves and buds. The Hessian Fly, as we shall see farther on, does not produce true galls in this way, but the presence of the insect in the flaxseed state, between the leaf and the stalk, causes the stem to swell, and the leaves to wither and die. The scientific name is *Cecidomyia destructor* of Say.

The female (Plate IV, *f;* V, *A*).—The body is rather slender, uniformly dark brown, the head is round, but somewhat flattened, the eyes are black, the wings uniformly dull smoky brown, while the legs are paler brown than the rest of the upper side of the body. The body, wings, and legs are provided with fine hair-like scales (Plate V, *A*, *c*), those on the wings being in many cases quite broad and ribbed, somewhat like the scales on the wings of a butterfly or moth. The pale brown antennæ are about half as long as the body, the joints are very distinct, like a string of beads, each one being oval-cylindrical. There are seventeen joints, the two basal ones being large, nearly globular, flattened lengthwise, and nearly half as long as thick, and each of nearly equal size; joints 3–5 are longer than the remaining ones, and are slightly contracted in the middle; the remaining 6–17 gradually decrease in length, each joint being provided with about ten hairs, arranged in a rude whorl; the terminal joint (Plate V, *A*, *a′*) is long and conical. The legs are of the same color as the under side of the body, being a little paler than the back. The abdomen is rather full, with nine well-marked rings or segments, the

paler small ovipositor forming the tenth. The latter is one-half as thick as the ninth segment, and about two-thirds or quite as long; is slightly sinuous, and a little smaller at the end than at the base. The wings are dusky, with a fine fringe around the edge, and there are three veins. The subcostal vein ends near the outer third of the wing; the median vein arises from near the base of the submedian vein and runs nearly parallel to the subcostal vein, while a branch (its base disconnected with the main vein) extends along the middle of the wing; the submedian vein is well developed, at the base throwing off the median vein at a little distance from the base of the wing, and losing itself before turning down to the edge of the wing. The length of the fly is 2.5 millimeters, or about one line, *i. e.*, $\frac{1}{10}$ of an inch.

The male.—The male is rather smaller than the female, being distinguished by the long, slender abdomen, and the longer and more hairy antennæ. The joints of the latter (Plate V, Fig. *A*, *a''*, *a'''*) are twenty in number, oval, the terminal one conical, and all provided with a few hairs, much longer than in the female, and arranged in a decidedly verticillate manner. "The abdomen in the living specimen is black or brownish black, with bands at the sutures both above and beneath, of a brick red, tawny yellow, or grayish color, varying in their width as this part of the body is more or less distended." (Fitch.) The claspers at the end of the body are stout, much more so than in *Cecidomyia leguminicola* of the clover.

The egg (Plate IV, *a*, enlarged) is very minute, about a fiftieth of an inch long, cylindrical, pointed at each end, the shell shining and transparent, the egg being of a pale red color when the embryo is nearly developed.

The larva.—After remaining about four days in the egg state, the larva or maggot of the Hessian Fly hatches, and is of the form represented by Plate IV, Fig. *b*, and Plate V, Fig. *B*, *Ba*, *Bb*, *Bc*.

The body is soft, smooth, shining, oval-cylindrical, beneath a little flattened, and consists of twelve segments besides the head, the latter soft, fleshy, and but slightly separated from the body, with very rudimentary mouth-parts (jaws, &c.). The rings or segments are moderately convex and tolerably distinct from one another; the sutures between the segments in the living larva being indicated by faint transverse lines of a greenish-brown hue, according to Fitch, who also states that the mature worm, freshly taken from the roots of the wheat, measures about 0.15 of an inch in length by 0.06 inch in width. Mr. Riley informs us that there are nine pairs of minute spiracles, which appear as yellowish, rounded tubercles.

The puparium or flaxseed state (Plate IV, Fig. *c*, Plate V, Fig. *D*).—When fully grown the larva is ready to transform into the third or pupa stage of its transformations. The body turns brown, and finally of a bright chestnut color, while the skin looses all appearance of sutures, and assumes a rude, spindle-shaped form, somewhat larger than the larva.

This brown case protects the growing pupa within the skin of the latter, finally separating from the cast larval skin, called the pupa-case or *puparium*, and which serves as a sort of cocoon to protect the pale, soft-bodied pupa within. While many two-winged gall-flies are protected by the galls within which they live, others, like the larval wheat and clover-seed midge and the pitch-pine midge, spin true cocoons of silk; and the Hessian Fly is the only species of the genus or family, so far as we know, which assumes this puparium state, which is characteristic of the house fly and other species of Muscidæ and allied families, in which the pupa is said to be *coarctate*, *i. e.*, protected by the cast dried brown skin of the maggot or larva.

From the decided resemblance to a flaxseed the insect, when at this stage of its transformations, is said to be in the "flaxseed" state. It is, however, rather flatter than a flaxseed, being pinched, as it were, at the head-end of the body. I have taken the semi-pupa or incompletely-formed pupa from the flaxseed December 1. In this flaxseed state the partly-formed pupa resides during the five winter months of the year.

In early spring, during warm weather in April, the semi-pupa rapidly transforms into the complete pupal or chrysalis state.

The pupa (Plate V, *C*).—As we have not personally observed the mode in which the fly issues from the pupa and its case, we extract the following account from Fitch. By the time the insect reaches the pupa state the flaxseed case has become quite brittle, breaking asunder transversely if rudely handled, one of its ends slipping off from the insect within, like a thimble from the end of the finger.

The time for its last transformation having arrived, the pupa, by writhing and bending its body, breaks open its puparium or flaxseed case, crawls from it, and works its way upward within the sheath of the leaf until it comes to some cleft in the now dead, brittle, and elastic straw. Through this cleft it crowds its body until all except the tip of the abdomen is protruded into the air, the elasticity of the straw causing it to close together upon the tip of the abdomen sufficiently to hold the pupa in this situation secure from falling to the ground; and, as if to preserve the body in a horizontal position, the feet are slightly separated from the abdomen and directed obliquely downwards, with their tips pressed against the side of the straw, thus curiously serving, like the brace to a beam or to the arm of a signpost, to support the body from inclining downwards. Thus securely fixed and now freely exposed to the drying influence of the atmosphere, the outer membrane of the pupa exhales its moisture, and, as it becomes dried, cracks apart upon the back or upper side of the thorax. Out of this opening the inclosed fly protrudes its head and thorax, more and more, as it gradually withdraws its several members—the antennæ, wings and legs—from the sheaths in which they are respectively enveloped—a process analogous to that of withdrawing the hand and its several fingers from a tight glove—until at length, entirely freed from its pupa-skin, the fly, now perfect in all its parts, usually walks a few steps farther up the straw, where it pauses for its body and members to acquire more firmness and strength by the further evaporation of their moisture, after which it is ready to spread its wings and mount into the air.

The Hessian Fly is easily distinguishable in all its stages from the wheat midge, which belongs to a different genus, *Diplosis* (*D. tritici* of Kirby). The wheat midge is orange-colored, has a stouter body, with

clear, transparent, and much broader wings, and pale-yellow legs, while the larvæ are orange-colored, and live crowded around the wheat-grains at the top of the plant; they spin a silken, round, genuine cocoon, smaller than a mustard seed, which remains in the ground just beneath the surface. So it will be seen that the form and habits of the two insects are very dissimilar, and that they need not be confounded.

HABITS OF THE HESSIAN FLY.

Having become acquainted with the appearance of this two-winged gall-fly in its different stages, we are now prepared to study its habits; for an intimate knowledge of how it comports itself as an egg, larva, "flaxseed," and perfect winged fly is absolutely essential to the farmer who would endeavor intelligently to combat this pest.

Number of broods.—The Hessian Fly is double brooded, the "flaxseeds" or puparia being found on the winter wheat from late in the autumn, through the winter, until the early part or middle of April. The "flaxseeds" of this brood, from one to about twenty in number, are situated between the stalk and sheathing base of the leaf, at the roots of the young grain, slightly beneath the surface of the ground.

The "flaxseeds" of the second generation affect the wheat in the late spring and summer; but are situated higher up, an inch or two above the surface of the ground, at the lower joints of the straw.

> In the ordinary course of nature, therefore [says Fitch], our crops of winter wheat are liable to two attacks of the Hessian Fly, one generation reared at its roots producing another, which occupies the lower joints of the stocks. Thus the larvæ and pupæ are present in it almost continually from the time the tender young blades appear above the ground in autumn till the grain ripens and is harvested the next summer. Our spring wheat, on the other hand, can rear but one brood of these insects; they consequently resort to it but little, if at all. Nor can the Hessian Fly sustain itself except in districts where winter wheat is cultivated in which for it to nestle during the autumn and winter.

As a general rule, then, there are two broods of the fly, the first laying their eggs late in April and in May, and the second brood of flies ovipositing[111] in August, during September, and perhaps a few early in October. Sometimes the flies appear earlier, as Professor Cook, who observed the insect in Michigan, says that "in July and August the flies again issue forth, and the cycle of changes for the year is complete. Thus we see that the flies are ready for work in the fall, much before the wheat is ready for them, and may attack a volunteer crop long before the usual crop is above ground or even sown."

A third brood may sometimes appear, as shown by Mr. B. Hulick, of Michigan. According to Professor Cook, Mr. Hulick found the empty "flaxseeds" on volunteer wheat in September. On Professor Cook's expressing

---

[111] Mr. F. S. Sleeper writes us that he has on one occasion seen the Hessian Flies laying their eggs as late as October 26. In February, 1878, during very mild weather, he observed them laying their eggs in February. See his statements, farther on.

some doubt whether the fly had issued, suggesting that it might be the parasite that had eaten the fly and come forth, as the time appeared to him too short, Mr. Hulick at once planted some of the volunteer wheat, still containing the "flaxseed," in close jars, and—

Saw many of the flies issue; and, more, had eggs laid by these flies on the same wheat in October. Mr. Hulick showed these flies and their eggs to several of his neighbors. In this case the eggs were deposited in July, the flaxseed state assumed in September, from which came a third brood of flies in October. This is certainly a very important matter, as it shows that three broods are possible under favorable conditions. That while the fall flies may, nay generally must, wait till September to deposit eggs, they only want opportunity to breed their mischief much earlier, even in July or August, and thus propagate a late brood of flies which will be in readiness for even the latest sown wheat. No doubt, too, as in the case of all insects, varying degrees of heat or cold will accelerate or retard the various transformations. (Lecture, &c., p. 9.)

Mode of egg laying (see Plate IV, *e*, the fly of its natural size engaged in laying its eggs on the leaf of wheat).—The mode of oviposition has thus been described by Mr. Herrick:

The eggs are laid in the long creases or furrows of the upper surface of the leaves (*i. e.*, the blade or strap-shaped part) of the young wheat plant. While depositing her eggs the insect stands with her head towards the point or extremity of the leaf, and at various distances between the point and where the leaf joins and surrounds the stalk. The number found on a single leaf varies from a single egg up to thirty, or even more.

Professor Cook says that—

The fly very rarely lays more than three eggs at one time without change of position. She more frequently lays two, and generally but one. In case she lays but one it takes less than a quarter of a minute, and less than half a minute to lay three, when they are all laid without a change of position on the part of the fly. After laying she seems to draw in her ovipositor soon to extend it again, at the same time crowding into it the one, two, or three eggs that are next to be laid. She then flies to another leaf, alighting usually, not always, with head towards the end of the leaf. She then appears to wipe the eggs off the jointed ovipositor. She really crowds the egg till the end touches the leaf, when by friction of the leaf and adhesion of the egg the latter is held fast while the egg-tube is withdrawn. If the second and third are to be laid she repeats the operation, after which she retracts her ovipositor, restocks it, and in a trice is depositing the fatal germs on another leaf. I say usually on the upper surface, for occasionally eggs are laid on the stalk, and sometimes on the under side of a leaf. I have observed that the fly often makes many unsuccessful efforts to cause the egg to adhere on the outer face of the leaf before she succeeds. I have seen a fly work thus for two minutes before success crowned her efforts. The fly may thus learn by experience that it is easier to deposit on the inner or upper face of the blade, and so generally choose that surface. We shall see, too, in the sequel, that it is better for the prospective maggot that the egg be placed on the upper surface. In four to ten days, more or less, as the weather is cool or warm, the eggs hatch. (Lecture, p. 7.)

Mr. C. V. Riley describes as follows the process in the New York *Tribune:*

I have very carefully studied the oviposition of the Hessian Fly, closely observing the female in the act on several occasions; and as accurate observations on this point are not easily made, I herewith transcribe my notes of several years ago:

Eggs deposited in irregular rows in the longitudinal cavities and depressions of wheat stalks between the stalk and sheath when this is loose, or on the leaves between the natural ridges or carinæ of the upper surface, this last being the more common habit. Ordinarily there are from five to ten in a row, but sometimes more. Each egg .02 inch long, cylindrical, rounded at each end, soft, translucent, and pale orange-red in color. Before hatching, the pale sides of the inclosed larva show through the shell. Larva hatched in four days; crawls down leaf to base of sheath, which on young grain is at crown of root. The orange-red color is soon lost, and the larva becomes pale, translucent, and plump, sinking more or less into the stalk by the depleting process kept up.

In an article in a Saint Louis paper I described, last June, the process of oviposition on the leaves, and my own observations in Missouri accord entirely with those of E. Tilghman recorded in 1820, and of E. C. Herrick in 1844, and quoted by Fitch in his essay on the Hessian Fly (Albany, 1846), with the exception that they do not mention the exceptional habit of pushing the eggs between the sheath and the stalk, owing doubtless to the fact that their observations were made solely on the autumn brood of flies ovipositing on the young plants, the habit being more common in the early summer brood when the plants are larger.

Mr. William Strong, of Kalamazoo County, Michigan, thus describes the process, adding some particulars of interest:

I have seen the wheat plant with many of the maggots at work before there was any stalk for the fly to lay its eggs on, by introducing its extensile abdominal tip under the leaf sheath. Even this fall I have seen this very thing when there was as yet but one shoot from the kernel, having but three leaves, the wheat having been sowed not more than three weeks. I have seen these maggots when too small to be seen without the aid of a glass, so low down towards the kernel, which was sowed with a drill, that if the fly had deposited the eggs under the leaf on the stalk, if there had been one there, she would have been obliged to use a spade to dig to get a chance. I am not the only one who believes that the egg is laid on the leaf and hatches there, when the small maggot works its way down inside of the leaf as low as possible. If there should be fifteen or twenty on one leaf (not a large number to find the past year under one leaf), of course as they took their places they would be somewhat in rows, but they, of course, are not the "eggs placed in the longitudinal grooves of the stalk."

In Solon Robinson's "Facts for Farmers," page 214, we read: "The female deposits her eggs soon after the wheat begins to grow, * * * in the cavities between the little ridges of the blades. In from four to fifteen days the eggs hatch and the diminutive maggots work down into the leaf-sheath and there spend the winter." In the *Kalamazoo Telegraph* for November 7, this year, are a few lines upon the Hessian Fly by M. B. Bateham, of Ohio. He is too well known to need an introduction at this time. He says: "In the spring, with the first warm weather, the fly will come forth and deposit its eggs upon the leaf, which will then soon hatch, when the worms, crawling down the leaf, feed upon the stalk, injuring its growth, often causing it to die." A reason given by some why the fly does not injure red wheat as much as white is because the leaf of the red grows so long and slants down from the shoot so that when the egg hatches the maggot works down the wrong way, falls to the ground, and so many fail to harm the wheat.

A writer in the *Country Gentleman*, Mr. Caleb S. Fuller, of Jackson County, Michigan, says:

The fly commences as soon as the wheat is up an inch high. I placed in a glass fruit jar some stools of wheat which was sown on the 31st of August, and about the 15th of October the fly hatched out of the brown eggs [puparia] which were in the wheat in large numbers, and was a lively little black fellow about one-eighth of an inch long. Now, if the eggs were deposited about the 8th of September, as that is as soon as the wheat would be large enough for them, it would give them about 37 days

to mature so as to fly again, though they might hatch a little sooner or later in the open field. I cannot say as to that; have no certain means of knowing.

The flies of the second brood are, in southern Michigan, ready to deposit their eggs late in April or early in May "on spring wheat or barley which is sufficiently advanced, in lieu of which they deposit on the wheat again, not on the basal or radical leaves, but on the leaves which will be above the first or second, rarely the third, joints." (Cook.)

Habits of the larva.—As soon as the footless larva or maggot hatches, it makes its way down the leaf to the base of the sheath, which, in the young winter wheat, is at the crown of the root.

Here [says Herrick] it fastens, lengthwise, and head downwards, to the tender stalk, and lives upon the sap. It does not gnaw the stalk, nor does it enter the central cavity thereof; but, as the larva increases in size, it gradually becomes imbedded in the substance of the stalk. After taking its station, the larva moves no more, gradually loses its reddish color and wrinkled appearance, becomes plump and torpid, is at first semi-translucent, and then more and more clouded with intestinal white spots; and when near maturity, the middle of the intestinal parts is of a greenish color. In five or six weeks (varying with the season) the larva begins to turn brown, and soon becomes of a bright chestnut color, bearing some resemblance to a flaxseed.

EFFECT OF THE WORM OR LARVA ON THE WHEAT.

As has been stated, the worm in autumn lies at the sheathing base of the leaves just above the roots, at or near the surface of the soil. It is easy to detect the flaxseed from its large size and chestnut-brown color, by separating the leaf from the stalk of the young wheat in October and November, when the worm has stopped feeding and is incased in its brown sack. Scattered shoots will be found, withered and changed to a light yellow color, and, as Fitch observes, strongly contrasting with the rich green of the vigorous uninjured plants. (See Plate IV, representing a healthy stalk on the right and a dwarfed plant on the left, containing three flaxseeds, with the leaves partly withered.) The worms, before assuming the flaxseed state, rest between the leaves and the stalk; their soft, fleshy, undeveloped mouth-parts do not enable them to gnaw the surface of the plant, but the sap is supposed to be absorbed directly through the walls of the body, and thus they are said to feed by imbibition; this weakens the plant and causes it to become unhealthy and turn yellow and die; moreover, although this point is disputed by Dr. Fitch, the presence of the worms causes the formation of a gall-like swelling or enlargement of the stalk, an abnormal growth of the plant being caused by the slight interruption to the flow of the sap. Of course when six or a dozen of these comparatively large flaxseeds are lodged under the base of the leaves the plant turns yellow and dies, as if the roots had been affected.

How a field of winter wheat may be attacked and affected by the Hessian Fly may be seen by reading the following account in the *Cultivator and Country Gentleman:*

Last fall the appearance of the wheat plant on different fields and locations was very different. On strong and level lands, little injury was shown. Hilly fields, or

where there was a ridge or worn point, or where the rock cropped nearer the surface, the wheat appeared injured or dead, as also when sown after spring grain, particularly oats. That the fly either enters the ground or remains in the dry stubble till the size of the wheat affords a lodgment, appears true. As an instance, I note the following facts: An acre of potato ground of 1876 was sown to oats in 1877. It was in fair condition, and a heavy crop was secured. Surrounding this piece of oats on three sides was a meadow, the highway bordering the other side. A good crop of hay was taken in June, and the field was all plowed in July. The after cultivation was the same, putting the field in an excellent condition for the crop. Seeding was through early in September, and in a few days the whole field was nearly covered with the growing wheat, and was very much admired, both for its beautiful green and its superior culture. All at once the wheat on the oat stubble was turning very yellow, in strong contrast to the deep green on the surrounding meadow. In the hollows, on the accumulated wash of ages, the wheat was very large and kept green and growing; while on the sharp points of knolls and hard clay ridges, it was nearly gone. On a piece of new land near by, where never a kernel of grain was grown before, no fly or injury could be seen.

The appearance of the fly was general, as soon as one or two leaves gave them a lodgment. Owing to the superior warmth and moisture of the entire fall months, wheat sowed on strong land tillered largely. The insects took the first tiller and stuck to it, while two and even four others came out and covered the ground. On poorer parts of the field the plant could not tiller so much, and here the injury showed most. Up to this date the crop has wintered well, a deep layer of snow now keeps insects and wheat alike. About the 1st of May this entire brood will be ready to deposit their eggs, and they will number millions.

That a field of wheat may recuperate after a favorable winter, and how such a field looks early in the following June, is well brought out by the following extract from the *Prairie Farmer*:

The early sown wheat that was badly eaten by the Hessian Fly last fall, but which has been apparently entirely recuperated by the remarkably favorable winter and spring just passed, is more seriously damaged by the insect than many farmers are probably aware of. I visited to-day a thirty-acre field, sowed on the 5th, 6th, and 7th days of September. Early in October it looked very badly—was yellow and showed bare ground in many places, and the plants for a long time seemed to be dwindling and growing smaller. The fine spring, however, brought it out apparently all right. It now stands five feet four to six inches high, very well headed, and seemingly good for from thirty to thirty-five bushels to the acre. I examined the field carefully in ten places, taking twenty wheat stalks as they stood in the drill row at each place, with this result: Number of stalks examined, 200; number of stalks containing the fly, 134, or two-thirds of the whole. Many of the stalks, however, had only one larva, and these will probably not be much affected. The insects are all of full size, of a chestnut color, and plainly visible in the lowest joint and the one next above—about twice as many were found in the lower joint as in the upper one. This, I suppose, indicates a loss to the crop of from 30 to 50 per cent.

We had heavy rains on the 8th, 9th, and 10th of September, I think, which suspended the operation of seeding till the 12th or after. This seems to be the dividing line, separating the fields badly damaged from those that escaped with little injury. In a part of the same field (potato ground) sowed, near the last of September, with the same kind of wheat, the number of plants examined was 100; affected with fly, 12. In other fields the rate was four to six to the hundred.

Many fields of Mediterranean are lodging. The Clawson stands well, and by

reason of its stiff straw and vigorous growth promises to withstand the ravages of the fly better than the more feebly-growing and weaker-strawed sorts.

ARVINE C. WALES.

STARK COUNTY, OHIO, *June* 7.

Another extract from the *Cultivator and Country Gentleman* bears directly on this important point.

There is a dispute among good farmers whether wheat injured by the Hessian Fly is irreparably damaged. Mr. F. C. Root thinks it is, as he says when the central stalk is eaten out the plant is either dead, or able to make only a feeble growth. If it makes a head, it will perfect only one or two seeds to a plant. Mr. Jesse Dewey qualifies this statement thus: *If the land is rich enough*, though the central stalk be injured, the wheat plant will stool, and from its side roots sends up stalks and perfect a fair crop. I have no doubt that both of these excellent farmers are right. On the great majority of fields, the injury to the wheat plant in the fall means the destruction of the crop. When the central plant has been injured, the side shoots have not enough vitality to perfect much seed. Yet there may be land rich enough to make a crop from the second growth, provided the Hessian Fly next spring is not numerons enough to do serious damage. Very much now depends on the character of the coming winter. A season which, under ordinary circumstances, would be favorable, may also save myriads of Hessian Flies. There was much more "crinkled" wheat last summer than usual, and I have little doubt that the cause is to be found in the heavy mantle of snow, which preserved a greater number than usual of the Hessian Flies through the winter. The wheat crop this fall would have suffered more than usual in any event, but the evil has been greatly aggravated by the warm and generally dry weather after wheat-sowing. We had no killing frost until near November, nor frost of any kind until the middle of October. With frosts in their usual season, and not sowing too late, there need be little danger from the Hessian Fly. But it is the poorness of the soil which leads farmers, year by year, to sow their wheat earlier in order to get a larger growth. Making the soil richer removes the difficulty by removing its original and principal cause.—W. J. F., Monroe County, N. Y.

INFLUENCE OF THE WEATHER AND FAVORABLE AND UNFAVORABLE SEASONS.

To properly discuss this very important subject would require an intimate knowledge of the meteorological conditions and the relative abundance or rarity of the Hessian Fly during each year since its first appearance in this country in 1776. All that we can say with our present exceedingly imperfect knowledge bears but slightly on this point and must be considered as simply provisional. We may here quote from the *Cultivator and Country Gentleman* what has been stated by Mr. Riley in speaking of the condition of the Hessian Fly in 1877:

The Hessian Fly is rather an insect of moist climates and mild latitudes; and therefore, unlike the chinch-bug, its multiplication has been favored by the cool and wet summers and autumns of the last three years. While the rainy period which as a general statement may be said to have commenced in May, 1875, and continued to the present date, and during which time there have neither been severe droughts nor continued summer heats, the chinch-bug has so nearly disappeared that its depredations have been scarcely noticed, the Hessian Fly has developed and thrived, and to the extent that if the weather favors—that is, if from now to harvest it should continue cool and moist or warm and wet—the damage likely to be done to the incoming

and the following crop can scarcely be estimated. But if dry weather prevails from this time to harvest, the damage done can hardly be considerable—and if it should turn very dry and hot, all danger from serious depredations from it may be cast out of the account, in measuring the outcome of the crop—since a certain amount of moisture is absolutely necessary for the successful development of the several stages in the growth and progress of this insect scourge. But then Professor Riley warned me against drawing final conclusions on insufficient data, it being quite possible that other forces and causes appearing might bring about a quite different and unexpected result. Nevertheless, there are many reasons for expecting a dry spring, a warm harvest, and a hot summer, and comparatively trifling damage to be done by the fly on the wheat harvest of 1878.—W. J. F.

The effects of drought on the Hessian fly has been noticed by Professor Riley, in the *American Naturalist* for November 1881, as follows:

It has long been known that the Hessian Fly flourishes most when the Chinch Bug flourishes least; in other words, that wet weather favors it. Moisture seems essential to the well-being of the larva. The prejudicial effect of drought has not hitherto been observed, that we are aware of, but was very noticeable the present year in parts of Ohio, where the puparia literally dried up. Our attention was first called to the fact of the general death of the insect in the "flaxseed" state by Mr. E. W. Claypole, of Yellow Springs, Ohio, and our observations subsequently confirmed his experience. The intense heat had not only desiccated the Cecidomyia, but, what is still more remarkable, in most cases the parasites also. We should like to hear from Professor Cook, of Michigan, and others, whether a like result followed the severe heat and drought in other parts of the West. The presumption is that the mortality was general and that farmers may expect immunity from injury for some years to come.

That this fly flourishes best in a rather warm and moist season is shown by its habits. The flies hover in the spring and autumn over the wheat-fields in countless numbers, especially at morning and evening, avoiding the direct heat of the sun.

PARASITES OF THE HESSIAN FLY.

How useful, nay indispensable, parasitic insects may prove in keeping the noxious ones within due limits is well illustrated by the case of this fly, for whenever it suddenly disappears from a given locality, this is usually due to the attacks of its parasites, and especially one Chalcid fly, the *Semiotellus* [*Homoporus*] *destructor*, first described by Say.

This is a hymenopterous insect, having four wings and belonging to the same order of insects as the saw-flies, four-winged gall-flies (*Cynips*), the larger ichneumons, and the wasps and bees. It is a member of the family *Chalcididæ*. As stated in our *Guide to the Study of Insects*, this is a group of great extent, the species being of small size; they are often of shiny colors, as the name of the principal genus implies, being either bronze or metallic. They also have elbowed antennæ with from six to fourteen joints, and the wings are often deficient in veins. The abdomen is usually smaller, and composed ordinarily of seven rings in the male, and of six in the female, the latter often having a short but visible ovipositor, a horny tube consisting of three pairs of stout bristles closely

united and forming a quite solid tube. Some species are wingless. There are 1,200 species of the family known in Europe, and there are, in all probability, at least 1,000 in the United States. Few of them are over a line in length.

Semiotellus destructor, male. (Plate IV, Fig. *i*, much enlarged.) The head is transversely oblong, or rather cubical, being rather wider than long, and slightly broader than the thorax when seen from above, being full, somewhat rounded in front, and hollowed out behind next to the thorax. The eyes are dull red, reaching, when seen above, behind the middle of the head. The antennæ are elbowed, and when bent back reach to about the middle of the thorax; they are yellow on the basal half, black beyond. In the male they are 10-jointed; the scape (joints 1–3) is pale, and free from hairs, while the flagellum (or joints 4–10) is blackish and clothed with dense, stiff hairs as long as the joint is thick. The fourth joint has at base a minute, indistinct, constricted portion; joints 5 to 9 are of equal length and shorter than the 4th joint; the 10th (terminal) joint is long and acute at the tip, and nearly twice as long as the 9th: it is subdivided, when seen under a $\frac{1}{8}$-inch objective, into five sub-joints, the 5th minute and acutely conical.

The thorax is about twice as long as broad, and widest at the insertion of the fore-wings; like the head, the crust is coarsely punctured. The fore-wings are broad, triangular, well rounded externally; the subcostal vein is very thick, being strongly marked, and after joining the costal or front edge of the wing for a short distance, just beyond the middle of the wing, is bent in towards the middle of the wing, ending in a knob-like expansion with a slight point extending towards the costal edge of the wing. Fitch represents a slightly marked vein extending to the outer edge of the wing, but this is absent in our specimens. There is an incomplete median and submedian vein, only perceptible under strong magnifying powers, the base of the median being quite disconnected from the submedian. In most of my specimens there was no vein extending from the subcostal knob to the end of the wing.

The legs are pale straw-yellow, the fore shank-joints (tibiæ) and toe-joints (tarsi) brownish; the third hip-joints (femora) are dusky on the basal half, while the hind terminal tarsal joints are brown. The abdomen is small, black, while the head and thorax are bright metallic green, sometimes blue. The abdomen is also smooth and polished, much flattened, oval, not so wide as the thorax, broad at the end and suddenly pointed (mucronate) at the tip. It has a large yellowish patch on the upper and under side of the second segment. Length of the body 2–2.6 millimeters (0.08–0.11 inch).

The female differs in her greater size and rather slenderer body, and the more club-shaped antennæ, the terminal joint being twice as long as thick. Between the 3d and 4th joints are two distinct, minute subjoints, the 2d shorter but wider than the 1st; joints 4–9 are shorter and less

hairy than in the male, while the 10th (terminal) joint is acute at tip, and subdivided into four subjoints. The abdomen is as long and as wide as the thorax, ending in a long, sharp point, the short but distinct ovipositor extending slightly beyond the tip of the body. There is a slightly marked pale spot above on the second segment. Length 2.4–3 millimeters (0.10–0.12 inch).

This parasite was first described by Say, his specimens occurring at or near Philadelphia; it was observed by Herrick in 1833, in Connecticut, and in 1877 we bred it from puparia of the Hessian Fly received from Ohio; and, as stated by Professor Cook, it is sufficiently abundant in Michigan to destroy the Hessian Fly in great numbers, and is probably distributed throughout the Hessian Fly area.

So destructive are this and other parasites to the Hessian Fly that as early as 1841 Herrick claimed that in Connecticut "a very large proportion, probably *more than nine-tenths*, of every generation of the Hessian Fly is destroyed by parasites." This work is mainly, we doubt not, done by the chalcid parasite under consideration. It is to this insect more than to any other means in nature that we owe the general immunity in certain years from the attacks of the Hessian Fly in most wheat regions, and to this cause that during certain years the fly is kept wholly within bounds. Few people, even naturalists, have any adequate idea of the good done by these minute parasites. What was the fact in Connecticut in 1841, and the few years preceding, has been the case in Michigan, according to Mr. F. S. Sleeper, of Galesburg, Mich., who writes us that the Hessian Fly was nearly exterminated in Kalamazoo County by *Semiotellus destructor*, nearly all the "flaxseeds" in the crop of 1877 having been destroyed by this friendly parasite. He writes us that in the autumn of 1877 he found these parasites in the wheat-fields in countless numbers, and that the perfect Hessian Fly was difficult to find.

No one since Herrick recorded his observations has made very careful observations on the habits of these parasites. He states that:

> It pierces the sheath of the stalk (making a hole too small to be detected by a powerful microscope), and deposits an egg in the pupa within. This is done chiefly in June. The perfect insect is evolved in the summer and autumn succeeding, eating its way through the puparium and the sheath of the leaf.

Herrick also states that a second parasite, very similar to the *Semiotellus destructor*, "but with mere rudiments of wings, is sometimes evolved from the pupæ of the Hessian Fly. I am in doubt whether it should be considered a distinct species or only a variety."

A third parasite was reared by Herrick in Connecticut. It is an insect of the tribe *Chalcidiæ*, whose genus he did not determine. Its habits were like those of Semiotellus, and wingless females of this species were also found.

A fourth parasite, noticed by Herrick, belongs to Latreille's tribe *Oxyuri*, but the genus was not determined. In habits it agreed with

the foregoing parasites, but it was evolved later in the year. Herrick adds that all the parasites mentioned "are likewise evolved in the spring from the Hessian Fly pupæ of the summer previous."

The fifth parasite has quite different habits. It was said by Herrick to deposit its eggs in those of the Hessian Fly. Herrick, its first discoverer, thus speaks of it:

> The insect is abundant in the autumn. I first saw it September 23, 1833, in the act of depositing its eggs in the eggs of the Hessian Fly. From subsequent observations it appears that four or five eggs are laid in a single egg of the Hessian Fly. The latter egg hatches, and the animal advances to the pupa state as usual, but from the puparium no Hessian Fly ever comes forth. This parasite forms within the puparium a silky cocoon of a brownish color.

It is probable that it is the species first discovered by Herrick in Connecticut which Professor Cook has detected ovipositing in the eggs of the Hessian Fly.[112]

> It is black and looks not unlike a tiny gnat. The female feels for the egg with her antennæ, and when found intrudes the fatal egg, which, I find, takes three-fourths of a minute; full three times as long as it takes the Hessian Fly. The little parasite is much longer, too, in finding the eggs than is the fly in laying them. I find that each egg receives one, two, or three of the parasite's eggs. The eggs of these latter are tardy in hatching, so that the larva of the parasite may feed on the maggot of the Hessian Fly, not her eggs. These pupate in the puparium of the fly.

Platygaster error Fitch?—Having received one of these egg-parasites from Professor Cook, I find it to be so much like the *Platygaster error*

[112] Our attention has been called by Mr. Howard to the fact that as a rule to which there is no known exception, egg-parasites issue as adults from the eggs of their host; and on reflection it seems to us that the Platygaster in question is entirely too large to be regarded as a true egg parasite, those known to be such being of minute size. Fresh and very careful observations are therefore needed on this point, and it is possible that both Herrick and Cook have been in error, and that the eggs were inserted in freshly hatched larvæ when little larger than the eggs. We append Mr. Howard's criticism:

"Fitch's description of *Platygaster error* (which name you apply to the so-called 'egg-parasite' in Bulletin 4) is so general that it will apply to almost any species of the genus. And now a word as to the egg-parasite. So contrary is it to all analogy in the whole group of parasitic Hymenoptera, to say nothing of the well-known habits of the genus Platygaster, that a parasitic egg should be deposited within the egg of a host and not hatch until the larva of the latter has issued, that I look upon the reported observations of Herrick, and especially of Cook, as in the highest degree improbable.

"1. No other case is on record, to my knowledge, where an egg-parasite does not issue as an *adult* from the *egg* of its host.

"2. European species of Platygaster are known to lay their eggs in *larvæ* of Cecidomyidæ only,

"3. The difficulties in the way of making such an observation as Cook records are practically insurmountable.

"The second point alone would, in my judgment, settle the matter, as the generic habits of parasites are very uniform."

Respectfully, yours,

L. O. HOWARD.

of Fitch (Fig. 9) that I refer it to that species, though with a doubt. This is probably also the parasite referred to by Mr. Herrick.

It is shining black; the head is finely punctured, rounded, and slightly broader than long, being about as wide as the thorax. The antennæ are about as long as the head and thorax; they are slender, but apparently a little stouter than in *P. error*, the penultimate joints being a little broader and squarer than he represents (and they are very different from *Platygaster tipulæ*), these joints not being "twice as long as thick," but only ¼ to ⅓ longer, much as represented by Fitch in his figure;[112½] the terminal joint is long, oval, not so wide as those just behind it, and it tapers to a rounded point. The thorax is rounded ovate, but little longer than broad, black, with the scutellum high, rounded and pitted. The abdomen is flattened, oval, twice as long as wide, being a little longer than the thorax, but not quite so wide. The legs are pitchy black on the femora; the tibiæ dull reddish-brown, darker towards the end; the tarsi are 5-jointed, dark brown, hairy, with the basal joint reddish at the base. (Fitch says the legs of *P. error* are pitchy black; but in the specimen before me they have a decided reddish tinge.) The wings are veinless, clear transparent, irised. Length 1.8 millimeters, being a little larger than Fitch's *P. error*, which was 0.05 inch long. I am disposed to refer this specimen to Fitch's species, but should it be found to be quite distinct, it may receive the name *Platygaster herrickii*. It seems to be a genuine Platygaster.

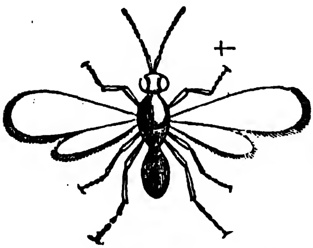


FIG. 9.—Platygaster of the Hessian Fly.

Fitch states that *Platygaster error* is seen in company with the wheat midge (*Diplosis tritici*) on the wheat ears in New York, and is very numerous some years, but he thinks it doubtful whether it preys upon the midge.

REMEDIES, PREVENTIVE AND GENERAL.

Having become familiar with the habits of this insect, which can be readily observed by farmers, it is not difficult to apply such remedies as the experience of wheat raisers of the past century in different parts of the wheat region of the United States has nearly universally found serviceable. Remembering that the first brood of flies appears in August and continues to hover over the fields until late in September, as if waiting for the fall-sown wheat to appear, it is evident that by delaying the date of sowing until after a frost cold enough to kill the flies, they may be circumvented; for if the wheat is sown later than the 20th of September in nearly all the Middle and Northern States, the early frosts will destroy these delicate insects. Late sowing, then, is the most general, important, and easily applied preventive remedy.

[112½] Sixth Report on the Noxious and other Insects of the State of New York, by Asa Fitch, M. D. Pl. 1, fig. 4, *a*, *b*. The figure is from Packard's Guide to the Study of Insects.

Late sowing of most of the wheat-seed.—All writers, both entomological and agricultural, concur in recommending this easily-applied remedy: that at least a part of the wheat should not be sown until after the 20th of September in the Northern States. The writings of Fitch, Harris, and of Cook concur in recommending this course in a district ridden by these pests, even though the wheat is in danger of being injured by the cold autumnal or the winter weather. As the year 1877 was a bad fly year, we quote the following explicit testimony from Professor Cook's pamphlet:

In all the century's experience in our country with this insect, this has been the most certain and satisfactory method to prevent its ravages. Even more than thirty years ago this measure is spoken of as unanimously sanctioned and the most efficient of remedies. During the past season [1877] I have reliable reports from the following counties: Ottawa, Van Buren, Cass, Kalamazoo, Hillsdale, Saint Joseph, and Lapeer, and with few exceptions it is stated that early-sown wheat was injured badly, while all sown after September 20 nearly escaped. In traveling through Ohio and southern Michigan, I found I could often tell the early from the late sown wheat for long distances, the former looking like oat-plants after a hard frost, the latter appearing green and healthy. Often in the same field the line of demarkation was very distinct.

The following newspaper extracts bear upon this subject:

Perhaps the most effectual remedy, or rather preventive, is late sowing. No wheat should be sown in localities where they have already appeared, or in districts adjoining until September 15, and if it is deferred until the 20th it would be all the better. Repeated rolling is said to destroy some of the larvæ, and burning the stubble, where practicable, would certainly destroy many and thus prevent so great devastation of the succeeding crop. The great objection to either rolling or burning is that it destroys both friend and foe alike.

Great care should always be used in destroying all noxious insects lest we also destroy the beneficial ones; the chief of which are the Ichneumon and Chalcis flies. In the counties of Yates, Seneca, Tompkins, and Cayuga, where the Hessian Flies have already made their appearance, it would appear wiser to fit the ground perfectly, apply extra fertilizers, and sow late, rather than run any risk or trust to any methods of destruction. If all infested and contiguous districts would sow late enough so that the wheat would not appear above ground before September 25, I believe the fly could be effectually starved out.—[I. P. Roberts, professor of agriculture, Cornell University, in the *Rural New Yorker*, September 8, 1877.

By the attacks of this (the second or spring) brood of worms, the lower joints of the wheat are weakened, and as soon as the head is formed, and the growth is heavy, the weakened joints give way and the wheat falls over, or, as it is commonly expressed, it "crinkles." If but few larvæ are at work, there will be some kernels of grain in the heads thus affected, but they will be more or less shrunken. If the insects are plenty, the head seldom "fills," and the field looks as if cattle or something else had passed though it, tangling up and throwing down the straw in every direction.

There are thus two generations of the Hessian Fly each year, one of which subsists and may be always found at the crown of the roots, and the other at some joint above, and never at the root. If the wheat could be fed off by sheep in the fall, between the time that the eggs are laid and the time of their hatching, this remedy would be perfect. Unfortunately, the wheat is then young, and farmers do not like to risk thus feeding it off. The only remedy left, therefore, is to sow so late that the wheat will not appear above ground before October 1. In this case there is the added risk of winter-killing, because the plants have not time enough to get well rooted before winter. On well-drained, rich land, this danger is greatly prevented, and therefore late sowing and thorough farming seem to be the only available means yet discovered to avoid great

losses from the ravages of the Hessian Fly. Fortunately the parasitic enemies of the fly increase rapidly, and after a year or two of great losses from this insect its numbers are reduced so much as scarcely to be noticed for some years.—[*Chicago Tribune.*

I find in several counties of northern Ohio, where I have traveled of late, a good deal of injury is done to the young wheat by the fly—more than has occurred before for quite a number of years. This is no doubt owing to the general practice of sowing wheat early, and the fact that it made a remarkably fine growth during September, when the warm weather was also very favorable for the propagation of the flies. The worms have now gone into the pupa or "flaxseed" state, and if the winter is not too wet or cold for them, it is likely the new brood next spring will prove quite mischievous.—[B., *Cultivator and Country Gentleman.*

Pennsylvania German farmers have a claim to be considered good zoologists by their knowledge of animals, from the noble horse down to the insect tribe, that so beset them with labor and loss. The German farmers have been apt and successful in contesting the insect enemies of all crops. The wheat midge, which came in upon us twenty years ago in vast numbers the last of June and the first of July, made his home in the wheat-heads, and nurtured his progeny in the cell prepared for the expectant berry, and appropriated the element nature designed for the perfection of the seed to his own use. This insect for a time literally destroyed the wheat product. Whether it was a scientific discovery that taught the farmers of Lancaster County how to get rid of this destructive insect or not, I have never learned. But I do know that I purchased and carried to my farm Lancaster red wheat which I was instructed to sow in August, and in doing so freed my farm of this pest. Continued early sowing proved successful up to the present season, when this practice brought the Hessian Fly, who begins at the root of the wheat plant. If the mother fly can get an opportunity to deposit its eggs in the fall season, the larva will stand the winter imbedded in a stalk of wheat (which is a well-tillered plant), and brings forth enough Hessian Flies to destroy the wheat before harvest time. The habit of this Hessian Fly is to bury in the ground with the first frost of the fall season. A Lancaster farmer said to me not long since, we must sow our wheat late this fall if we would avoid the fly. Early-sown wheat was a failure in Pennsylvania to an extent, in my estimation, that reduces this cereal 30 per cent. below our general average. The corn crop over the entire State is not an average one. The oat crop is above the average. The buckwheat crop, generally relied upon in the northern and western portions of our State as one of the paying bread grains, has been very extensively injured by the grasshopper, and cannot be expected to yield more than one-half the usual amount.—[V. E. Piollet's address before the Berks County Agricultural Society, at Reading.

The letter below from W. B. Billings to the Elmira (N. Y.) Farmers' Club, elicited the appended discussion, as reported in the *Husbandman*:

I have perused your club reports with much interest, especially those relating to the Hessian Fly. In an experience of fifteen years of wheat raising I have had about four acres of wheat destroyed by this pest. Eight years ago I sowed a field of ten acres to wheat, four acres of which were gravel, the remaining six acres being of sandy loam, in places so wet that I had to under-drain it. Wheat put in in good condition; land new—had been in cultivation only the two previous years. Now for the results: During the fall the wheat on the gravelly part started quicker, and when winter set in looked better, the fly doing no appreciable damage to any part of the field; but in the spring when the wheat had apparently reached about six inches in height, that on the gravel commenced turning yellow about the roots, and from that time forward grew thinner and most beautifully less until harvest, when I cut it with a mower and raked it with a wheel-rake, getting about as much straw as farmers generally get from raking a like amount of ordinary wheat stubble. On the remaining part of the field the wheat was good, no noticeable damage being done by the fly. A few years previous

Hessian Fly, less wheat being harvested than was sown. It is generally conceded that there are two crops, or hatchings, of the fly during the growth of the wheat: the first in the fall and working until frost comes; the second in the spring, and continuing its depredations until harvest. Late sowing is generally recommended as a preventive. Why should it be so? How do you account for the fly working in wheat growing on warm gravelly land, while that on the moist soil escaped harm? If, as above assumed, there are two crops of insects hatched per year, how does late sowing prevent their depredations? And how can you account for the loss of the spring wheat crop mentioned? Where was the first or small crop hatched, and where did the flies remain until spring? Fresh lime is recommended as preventing the ravages of this pest; can you tell me at what particular time, spring or fall, the lime should be sown to cause the greatest destruction of the fly? Any information from the club on the subject will be thankfully received.

J. S. VAN DUZER. It must not be assumed that the flies which damaged the spring wheat were hatched in that field. The parent flies may have come from a distant field.

President HOFFMAN. To my mind the case is easily explained, so far as the spring wheat is concerned. The fly is migratory. We are told by those who have studied its habits that it flies over districts as much as twenty miles in breadth in the course of the year.

The writer furnishes the explanation of the greater damage done by the fly on his gravelly land. There the wheat came earlier, and was therefore in condition to receive the deposit of eggs, while the more backward wheat was not. It accords with the theory that late sowing is a measure of prevention against the ravages of the fly. I had last fall an illustration of the protection afforded by late sowing. On a small piece I wanted to sow wheat after wheat. Before plowing the stubble the volunteer crop had made a growth of perhaps six inches. In examining one of the plants I found twenty-five of the larvæ. In many others there were a dozen or more. I destroyed this growth by thorough cultivation, and, after proper fitting, sowed the seed. In the plants that came from that late sowing there were very few larvæ. They came too late to receive the eggs. It is well known that the fly deposits the eggs on the leaves of the wheat, and that its work ceases after some frosts come. The late sowing brings the growth too late for the fly. The fly which does the mischief in the spring is not hatched in the fall—or at least is not fully developed. It comes out in the spring, lays a new crop of eggs on the leaves of the growing plants, and the insects which hatch from these eggs are those which do the real injury to the wheat. If the time can be ascertained when the eggs are deposited on the leaves, then is the time to sow lime. I do not know that it will prevent the eggs from hatching. My observation of the work done by the fly has taught me one lesson. It is that no wheat should be sown except on rich land, where the plants will be strong and therefore able to resist the ravages of the insects.—[*Western Farmer's Journal, March* 29, 1878.

It should, however, be borne in mind that late sowing exposes the wheat to the attacks of the wheat-midge (*Diplosis tritici*) and also to the rust, while also by late sowing the plants are less advanced and less fitted to withstand the rigors of the winter.

Early sowing as a remedy.—Still there are some who adhere to early sowing, as on the whole the best thing to do. We insert the following testimony in favor of this procedure:

In your paper of December 6, 1877, there are three or four articles respecting the Hessian Fly, and they are so different from my observation of the wheat insect, as we call it here, that I send you a few lines respecting the damage done to wheat here. The last harvest was very much injured in some localities in this State; in the west part of Calhoun County on sandy land some pieces were not harvested, and others

yielded from five to ten bushels per acre. In this part of Jackson County wheat did not suffer so much; some fields on bur-oak soil yielded as high as 35 bushels per acre of the Clawson variety.

The fly commences as soon as the wheat is up an inch high. I placed in a glass fruit jar some stools of wheat which were sown on the 31st of August, and about the 15th of October the fly hatched out of the brown eggs which were in the wheat in large numbers, and was a lively little black fellow about one-eighth of an inch long. Now, if the eggs were deposited about the eighth of September, as that is as soon as the wheat would be large enough for them, it would give them about 37 days to mature so as to fly again, though they might hatch a little sooner or later in the open field. I cannot say as to that, having no certain means of knowing. Now if we wait till the first of October to seed we will be just in time for the first brood that comes out in the fall to deposit their eggs in the late sowing, which was the case hereabouts. Fields sown on the 25th of September, 1876, suffered more than that sowed on the 25th of August the same year, not three miles apart; the latter giving a good crop, and the former a very light one.

Now, my observation as well as practice is, that the earliest seeding is the best every time. There are a few farmers in the country who invariably sow early—say as early as the 25th of August—and they hardly ever fail of a good crop. There may be a difference in varieties in resisting the ravages of the fly, and I presume there is. The Tappahannock suffered very much more than the Clawson in adjoining fields, on the same farms, and sowed about the same time. I venture the suggestion that we all sow our wheat earlier—say on the 20th of August, or soon after—as farmers used to do 50 years ago, so that our wheat will get a strong root and a large top to go into the winter with. I hope this suggestion will stir up some scientific man, like Professor Riley of Missouri, to investigate the habits of the fly as thoroughly as he has the locust or the Colorado potato beetle, for I think the country has suffered quite as much from the Hessian Fly as from all other pests put together. If this brings out the desired information, I shall be well paid for this my first contribution to your valuable paper, which I have read with great pleasure for the last ten years.

CALEB T. FULLER,

JACKSON COUNTY, MICHIGAN.

In reply to your request for information in regard to the Hessian Fly, I will state that only a few of the earliest sown pieces are affected in this and the adjoining county of Trimble. Wheat in general looks remarkably well, has tillered finely, and there is at least 15 per cent. more than an average acreage sown.

S. E. HAMPTON.

CARROLL COUNTY, KENTUCKY.

[*Cultivator and Country Gentleman.*

We may, then, conclude that, on the whole, late sowing is the best general remedy, but still a part of the wheat should be sown early as a decoy to draw off the flies and induce them to lay their eggs in the early-sown grain, that the later-sown portion may escape their attacks, and then farmers should plow under and resow the fields of early grain. Hence we indorse the following excellent advice, which was first suggested by Dr. Fitch, and reiterated by Professor Cook, as follows:

Let all, without exception, sow a narrow strip about each field, to be sown early in September, or even in August. From the fact that the flies are already in waiting, that the outer edge of a field is almost always the most injured, except that the field grew wheat that nourished flies the preceding year, and that such fields suffer most, one may expect this early-sown narrow rim to receive nearly all the eggs. Leave the balance of the field till we feel it is dangerous to wait longer, at least till after the middle of September, then sow it, after which plow deeply under the early-sown strip,

that is if it is stocked with insects, which may be easily determined by examination, and resow it. We should thus kill two birds with one stone—save our crops, and destroy the pest.

Advantage of high culture.—Many farmers advocate high culture, sowing a less breadth of wheat, and cultivating the ground, using fertilizers. This is all-important, as the stronger and more luxuriant the growth of the young wheat, the better able will it be to withstand the weakening effects of the maggots; while high culture will carry a partly infested field of wheat through, when the same grain grown on a poorer soil would succumb. The value, then, of good farming, conducted on scientific principles, the forcing of the plant by fertilizers, and the rotation of crops, is so self-evident that we need devote no more space to this subject, except to add the following remarks by practical farmers:

It is claimed by some that certain varieties of wheat are less liable to the attacks of the Hessian Fly, and entire exemption has been claimed for some. I am satisfied from experience that these claims are partially fallacious. There is no wheat which the fly will not injure under favorable conditions for its working. The supposed exemption is due to the fact, that when a weak-growing and strong-growing variety are sown side by side, the fly leaves the latter for the former. Whatever makes the wheat plant vigorous, helps to repel the attacks of all insect enemies. If the red sorts are less liable to injury, it is because their thicker and ranker leaves keep the plant too moist for the eggs and larvæ. I have seen the same result from the use of superphosphate, gypsum, salt, and in fact any manure which causes vigorous growth, with dampness. Coarse manure sometimes seems to favor the insect, but only, I imagine, when the weather is so dry that its coarse strawy substance is really more dry than the ground. Wherever the soil is moist, and wheat makes a rapid growth, the fly will do least damage. I shall take advantage of this fact, this fall, in fertilizing my wheat more liberally than ever before, using two hundred, or perhaps more pounds, of phosphate per acre, besides gypsum and salt to dilute it. If I can get a vigorous growth of wheat from the start, there will be less to fear from the fly. This liberal manuring will also enable me to defer sowing till later than would otherwise be safe.

Rolling and compacting the ground is very important as a means of keeping it moist. I shall not roll immediately after sowing, but wait until the wheat is up, when, if there is a dry time, with no frosts to keep back the fly, I shall roll the ground with the hope that the roller will destroy at least some of the eggs which the fly may have laid. W. J. F.

MONROE COUNTY, NEW YORK.

[*Cultivator and Country Gentleman.*

In the rapidly increasing practice of extra manuring and cultivation of wheat, as by drilling and hoeing, it is found in very many cases that the Hessian Fly and other insects are far less troublesome than on the wheat fields where only ordinary cultivation is practiced. It frequently occurs, too, that superior cultivation permits of earlier sowing in the fall; the extra growth more than offsetting the damage done by the insects, to avoid which most farmers now are obliged to resort to late planting. Several examples are cited where drilled and cultivated fields, grown beside ordinary broadcast-sown and lightly-manured fields, with results wholly in favor of the former, the Hessian Fly greatly damaging if not totally destroying the latter, while the cultivated fields escaped almost unharmed.—[*Cultivator and Country Gentleman.*

Pasturing with sheep.—Many farmers practice pasturing wheat-fields with sheep or cattle; for it is claimed that if the wheat is strong enough by the middle or end of November to bear it, enough of the larvæ or flaxseeds may thus be destroyed to save the wheat and prevent the ne-

cessity of plowing it in. This is a rather rude, uncertain remedy, but can be carried on with more or less success in the Middle States. We give the opinions of those who have found pasturing successful.

From Mr. E. A. Hickman, of Independence, Mo., we obtain the following information:

In reply to your inquiry on the subject of the Hessian Fly, I will state that I have made some inquiry of our best wheat-raisers, and they report as follows: First, the wheat-midge is not found in our State, hence is not further alluded to. A. L. H. Crenshaw, now an old wheat-raiser, and quite successful, says he breaks up his ground in July and lets it lie till September, then harrows it into good planting condition, and lets it remain until after a *killing frost*, which is usually from the 25th September to the 5th of October; then he puts in the seed by drilling. He has never lost a crop or had one injured by the fly.

G. W. Compton is a successful raiser; he breaks up in July, and by the 1st of September sows his wheat immediately, and as soon as the wheat is up and of sufficient height he turns sheep and other stock on it to keep it eaten down so that the fly cannot shelter under its leaves. This has protected his crop until the fall of 1877, when the rains favored the breaking up of the ground and the planting and growing of the wheat to such an extent that the stock could not graze it down. Its rankness protected the fly and its abundance nearly destroyed his crops. He attributes his failure to the fact that his crop was not grazed sufficiently close.

Mr. James Lobb sowed early in September, 1878, a fine growing season; brought up a luxuriant and vigorous stand; no pasturing was applied either in fall or spring, and the crop only yielded about four bushels per acre, the balance being destroyed by the fly. This was adjoining a field that produced a fine crop, but cultivated to thwart the fly.

Two other successful men say they have followed the advice of an old settler, who told them to have everything ready, but never sow until after a *killing frost;* and they never suffer from that enemy.

Mr. Robert McNeilly, of Charlotte, Dickson County, Tennessee, writes us that "the best preventive found here is to pasture the wheat close in the winter with sheep."

We also reprint the following newspaper articles:

Another error is that pasturing will do no good. If sheep enough are turned in to eat the wheat down close before the eggs hatch, after being laid, very much good will result. This is an old remedy, and has proved very effectual in many instances. It is now too late to employ it, as the eggs are mostly hatched. During the fine weather of this fall, so far, very few days only were required to hatch the eggs, after which nothing could be done. Very few eggs are placed too close to the ground to escape the teeth of sheep, and if enough of these animals could be turned on to eat the wheat off within three days after the flies appeared, very little damage would result. Frost now will not do much good except with fields that have been sown late, where the blades have not grown large enough to attract the fly. The destruction of the entire crop does not follow the appearance of the fly always. Unless very badly infested, if the soil is rich and the season favorable, a fair crop may result in spite of the fly. Of course, the crop is always injured to some extent. The best remedy, after the larvæ have hatched and found security in the crown of the plant, is to stimulate the ground as much as possible by the application of fertilizers.

We mentioned in last week's issue that the Hessian Fly appeared in Pennsylvania as well as in Canada and other sections last year. It appears that the practice of early sowing has lately increased so much in Pennsylvania as to furnish everywhere the young winter wheat at exactly the time when the Hessian Fly is laying its eggs. This probably has a good deal to do with the trouble in Canada also. And yet the

evils of late sowing are so great that most farmers would prefer to risk the Hessians. A correspondent of the *Germantown Telegraph*, speaking from experience—for he says that he has never known his system to fail both to destroy the fly and to greatly benefit the crop—gives a useful hint. He says that if the land is strong, the eggs of the fly may all be destroyed and the crop greatly benefited in this manner: After frosts cease in the spring, and the grain is beginning to grow rapidly, and the ground has become so dry that tramping will not injure the crop, pasture off the grain down to the crown of the plants with sheep. This will remove all the eggs, and it will cause the plants to tiller profusely, often five to seven to one, and all starting together will each enjoy equal facilities for growth and maturity, and the crop will be greatly improved and increased. If the soil lacks fertility, it is well to apply a proper amount of a proper fertilizer when the sheep are removed. If no salt has been applied to the land, no application will be more likely to pay so well as this, at the rate of twelve to twenty bushels per acre. This is well worth trying.—[*Canada Farmer*.

Sowing of hardy varieties of wheat.—When the stalks and leaves of certain varieties of wheat are tough and hard, the stems coarse and silicious, and the plants "tiller" or throw out secondary shoots in a vigorous way, such varieties are naturally the most fly-proof and should be selected for sowing as winter wheat, while the less hardy and vigorous kinds should be sown when the attacks of the Hessian Fly are not to be expected.

Of the different varieties of "fly-proof" wheat, the Underhill variety has for nearly a century been highly recommended. As Fitch remarks, its fly-proof qualities were supposed by many to be due to the hardness or solidity of its straw. The fly laid its eggs freely upon the leaves, but it was seldom if ever materially injured by it. It is a bearded white chaff, with a plump yellow berry, requiring to be thoroughly dried before grinding, and then producing flour in quantity and quality equal to the best of the other varieties.

The Mediterranean wheat is, in the Middle States, in high repute for its fly-proof and hardy nature, recovering better than other varieties from the attacks of the fly. A correspondent in Charlotte, Tenn., writes us that "the Mediterranean, Red Chaff, and Red May are less liable to be damaged by the fly than any we have tried." Fitch says the Mediterranean wheat is a slight red chaff, having a long stiff beard, a long, red, and very flinty berry, and ripens about ten days earlier than other varieties. In central New York the Lancaster, a red variety, is strongly urged.

In Michigan the Clawson is apparently the favorite wheat, on account of its "fly-proof" qualities. As stated by Professor Cook—

The fact that last summer (1876), as well as this, when Diehl and Clawson were sown side by side, Clawson was comparatively free from insects, and, as stated by Mr. Rowe, did not break down in summer, seems to show that it is more exempt from attack. It would seem that the insects have a preference, but will accept plain fare rather than starve or fail to produce. It also seems clear that Clawson, Lancaster, and the red varieties will stand attack with far less damage, owing to their vigor and greater tendency to sprout.

He then gives the following advice:

If wheat must be sown early, so long as the Hessian Fly remains a pest, by all means sow Fultz or other varieties of red wheat, or, better still, Clawson. But if we

act more wisely still, and set the trap of an early-sown strip, let this be sown to Diehl, the better to attract the flies, and then, when we sow the balance of our field, two or three weeks later, sow Clawson or other rapid, vigorous growing varieties, which not only resist attacks better, but survive better when attacked. Lastly, if the early sown area is harboring the pests, convert it into an insect cemetery, using the insects to fertilize a still further crop of Clawson.

Mr. W. L. Devereaux, of Clyde, N. Y., gives us his experience with the fly and the best varieties to sow:

Now, concerning the fly: It is the least to be feared of all the injurious insects of the United States. I am situated in or just north of the starting point of the *Cecidomyia destructor* in this last crusade on wheat, which is Seneca and Tompkins Counties, New York, between Cayuga and Seneca Lakes. This section is also where the *Clawson* wheat originated, and I hold that the Clawson has been the propagator of the fly in this last spread. Perhaps the Soules helped the spread prior to this.

To my knowledge, there isn't a single instance of a field of Lancaster being injured by the larvæ of the fly. Indeed, I never could find a single larva or pupa in a field of Lancaster. It is the kind which farmers have sown almost entirely throughout this section this year. It does well, and, although a red wheat, it now commands as high if not higher price than Clawson.

I would particularly impress upon you the fact that we think the fly cannot be found on Lancaster wheat. It is a variety which is extremely tough and hardy, having that green color which farmers call "black," while the Clawson and similar wheats have a green color which is very often yellow. The Lancaster—to strongly indicate its toughness—is said to grow readily under water or on a rock. I have no personal motives in writing thus of the Lancaster wheat; I only want to indicate that it is too tough fibre for the Hessian Fly to live on. It is nearly like or is the *Blue-stem wheat.*

Professor Cook ranks the Clawson as being less injured by the fly than the Lancaster, but I think the latter is absolutely free from the fly, while the Clawson is literally eaten up alive by the fly.

Mr. Devereaux afterwards wrote as follows, under date of October 29, 1879:

The Hessian Fly has not destroyed wheat to any great extent this year. However, all white wheat suffered from the attacks of the fly, but still not to the extent it did last year. Red wheat has never been attacked (*vide* my article in *Rural New Yorker*, June 15, 1878). The principal bearded red wheat sown in this locality is called the Lancaster. An amber wheat called Fultz (a bald wheat) seems to be proof against the fly. Mold's red wheat (bald) is also not attacked. But the Clawson (white), so extensively sown here and elsewhere, was most severely attacked in 1877, very badly in 1878, and this year it was thought to be free from the fly, but when harvest came it was noticeably short, many heads unfilled, many stunted in their height. At this date of writing every piece of Clawson sown this fall is being ravaged (however, there are only a few pieces of Clawson for miles around here), the Lancaster, as heretofore, remaining uninjured.

I notice after harvest long stubbles and straws of wheat in field and barn-yard which have many little pin-holes from which the imago Cecidomyia escaped. Barley was damaged to an enormous extent last year, whole fields having nearly every straw so badly damaged that they would break off readily by passing through with the horse-rake, throwing it into winrows. This year barley was not hurt much.

Now, wasn't the great spread of the Hessian Fly, which occurred many years ago, brought about at that time by that extensively sown wheat, the *Soules*, which was a very similar wheat to the Clawson, which brought the fly this time? Or, rather, each kind of these wheats, by their tender foliage and loose culms, allowed the rapid propagation of the fly, being their favorite variety of wheat; we may also add the fact that these wheats were popular among the farmers everywhere; thus whole wheat district were sown entirely to this wheat, bringing forth countless numbers of the Hessian Fly

to every acre. In the former spread of the fly, farmers entirely desisted from raising wheat, or resorted to red or Mediterranean wheat, and so the pests can be driven back now to their less prosperous plants by the sowing of Lancaster and similar wheats.

In conclusion, we may urge that whatever kind of wheat is used, much more depends on a rich soil, a vigorous growth, and careful cultivation, all of which tend to make the stalk stouter, and the growth a few days earlier, than the choice of particular varieties.

SPECIAL REMEDIES.

Under this head belong the use of lime, dusted on the young wheat, rolling, deep plowing, burning the stubble after harvest, &c. Such special remedies as these are of little use as compared with careful preparation of the ground and late sowing, and some of them actually do more harm than good, as we shall see further on.

Application of lime to kill the maggot or larvæ.—It has been frequently recommended to spread fine lime, soot, or salt upon the young wheat so as to kill the young larvæ. As a sample of such treatment, which at least can do no harm, we extract the following statement from the *Kansas Farmer*:

The farmer who recommends the remedy is a Virginian, and he writes to a local paper as follows:

"I hear there is much 'fly' in the wheat that was sown early this fall. To correct this evil I offer the following remedy, which I and others have successfully tested for a good many seasons: Sow of air-slacked or water-slacked lime one or two bushels per acre broadcast over the wheat in the early morning on the dew, or over night on a clear evening, when there is reason to expect dew or frost. As it dissolves it will form a lye which will follow the leaf towards the root and destroy the chrysalis of the fly near that point.

"The sower must always sow with the wind, else the lime will be blown back in his face and eyes and on his clothes. And he must grease his hands, face, and nostrils with lard, which renders contact with the lime innocuous. If two or more sow they should sow *en echelon*, at such a distance that the rear shall cast no lime on the front. A very good but not indispensable plan is to use tea scoops—diminutive sugar scoops—that will hold a double handfull. It enables one better to take up and measure the quantity to be applied. This is an application so simple and cheap as to discredit it with the many who are often looking to be told 'some great thing.' I can only say that I know it to be effectual as a remedy, and that in no case can it do harm."

It is evident that such remedies as these should be applied before the insect transforms into the flaxseed state, as the hard, dense pupa case is impervious to ordinary appliances such as would kill the maggots.

Rolling the ground to kill the larvæ and flaxseeds.—Practical men advise rolling the ground both to keep it moist and in order to destroy the eggs, larvæ, and some of the flaxseeds. This may be in some cases worth trying, but we should think that full as much injury would be done to the wheat plants as to the minute larvæ and eggs upon them.

Cutting the grain close to the ground.—This has been sometimes practiced. A writer in the *Ohio Farmer* makes the following statement in favor of this plan:

E. C. Green, Medina County, Ohio, writes: "The Hessian Fly appeared in this vicinity, but has done but little damage. The wheat commenced to fall over before it

was cut, and the eggs or larvæ were found above the first or second joint. The damage on five acres of wheat was probably five or six bushels. By reaping low and raking the stubble was all saved."

A serious objection to reaping low is that many insects of the summer brood in the flaxseed state are, as Mr. S. S. Rathvon claims, carried to the barn or stack, beyond the reach of remedy. From the straw thus harvested the fly would emerge before it was threshed, "and might even pass through a machine without injury." In this manner the fly has possibly been distributed through different sections of the country.

Burning the stubble.—Although this remedy has been advocated, it will be seen to be worse than useless when we reflect that after all the artificial means taken to reduce the number of the Hessian Fly, nature's method of checking its undue increase is far more important and thorough-going; we refer to the diffusion and multiplication of the insect-parasites. As previously stated, most probably nine-tenths of the young Hessian Flies are destroyed in the larva or pupa state by the parasites already described. For the most part these parasites live in the flaxseeds contained in the straw, and appear in spring. Now, to burn the stubble in the autumn or early spring is simply to destroy these useful parasites, the best friends of the farmer. We do not hesitate to urge that the straw be untouched. On the contrary, the parasites should be gathered and bred in numbers; and we believe that practical entomologists should bend all their energies towards clearing up the subject of rearing and multiplying these insect hosts. Much knowledge and practical skill is needed in this direction, as occasionally by disseminating the parasites their noxious hosts may increase and be distributed; but knowing, as we do, how many more of the parasites are in many cases bred than the insects on which they prey, it seems safe and reasonable to advise not only not burning the stubble, but letting it stand, so that the parasites may finish their transformations, become fledged, and ready, when the eggs and larvæ of the Hessian Fly are upon or in the young wheat, to destroy them.

It is a matter of fact that in years when the Hessian Fly is specially abundant and destructive, similar seasons are highly favorable to the corresponding increase in the number of their insect or ichneumon parasites; they do their work so effectively that the few following years the numbers of Hessian Flies are greatly reduced. It is, then, to these parasites that we are indebted for the yearsof immunity from the attacks of the Hessian Fly, as much as to favorable or unfavorable weather, and this leads us to consider the apparent *periodicity* in the years of abundance and scarcity of the Hessian Fly.

PERIODICITY IN THE ABUNDANCE AND SCARCITY OF THE HESSIAN FLY.

The following tabulâr view, though constructed from very scanty and often misleading data, maÿ throw some light on this subject.

The table has been drawn up from the reports of Fitch, Hind, Cook,

and of the Agricultural Department at Washington, and from different newspapers, as well as from private correspondence. The record, as therein presented, is very imperfect, but still is sufficient to show the periodicity in the return of periods when the Hessian Fly has been sufficiently abundant to ravage wheat-fields and excite apprehension and alarm. Without much doubt, in the different States mentioned, especially in the Middle States, the insect is tolerably abundant nearly every year, but few seasons occurring when after a careful search by experts the fly would not be found.

As the recorded facts indicate, within about ninety years there have been, in the Atlantic and Middle States, six periods of unusual abundance, namely, centering about the years 1790, 1817, 1844–'45, 1871–'72, and 1876–'78. These dates, which generally are inserted in larger type in the table, mark the time of culmination in the degree of abundance and extent of ravages committed, and were preceded by from one to several years of less or greater abundance. After the culmination, or year of greatest abundance, the fly often suddenly disappears. This sudden disappearance is, without doubt, due to the great increase in the number of parasites, while the original increase is probably due to a succession of warm, damp seasons, favorable to the multiplication of the flies. These seasons, when we look at the later Hessian Fly years, such as 1844–'45, 1871–'72, and 1876–'78, when the insect had become widespread over the western portion of the wheat area, were evidently areas of similar climatic features common to the Atlantic and Mississippi Valley States. Whether these seasons were warm and moist or not, we have not the means at hand to enable us to form an opinion.

As stated to us by Mr. Thomas, in 1817 the rainfall from Maine to Maryland was slightly above the average, 1.01 per cent. of the mean.

The winter of 1843–'44 was the most severe in the West that had been experienced for twenty years; the spring was cold and late; 1844 was very wet over the West, in fact the wettest season known since its settlement, or at least since 1811. This was the year of the great flood in the Mississippi. It was also wet in parts of Virginia and Maryland. But along the sea-coast, from Maine to Florida, the amount of rainfall was only about .90 per cent. of the mean. In 1845 it was not very wet in any section where wheat was cultivated, the amount along the sea-coast being placed at .95, and this was about the same in the Middle and Northwestern States, varying from .83 to .91 per cent. of the mean.

We thus see that the Hessian Fly years, 1817 and 1844, were wet years, periods of more than the average rainfall. Of 1871 we have no records at hand; the spring and summer of 1877 were damp and wet, and also appear to have been warmer than the previous year. There thus appears to be a correlation between the seasons of greatest abundance of Hessian Flies and a greater degree of moisture, if not of heat.

Chronological table of Hessian-

New York.	New Jersey.	Pennsylvania.	Delaware.	Maryland.	Virginia.	West Virginia.	Connecticut.	North Carolina.	South Carolina.	Ohio.	Indiana.	Illinois.*	Michigan.
1778													
1779													
1780													
1781													
1782													
1783													
1784													
1785													
1786	1786	1786											
1787	1787	1787											
1888	1788	1788											
1789		1789											
1790	1790	1790	**1790**	**1790**									
1791			**1791**										
1792			**1792**										
1793													
1794													
1795													
1796													
1797		1707								*1797			
1798													
1799													
1800													
1801					1801								
1802					1802								
1803					1803								
					1804								
1810													
1817		**1817**		**1817**	**1817**								
1830		1820		1820									
1831				1830									
							1833						
1835	1835	1835		1835	1835								
1836	1836	1836		1836	1836								
							1837						
1840		1840		1840	1840		1840	1840		1840			
1841		1841		1841	1841					1841			
1842		**1842**		1842	1842					1842			
1843		1843		1843	1843					1843			1843
1844		**1844**		1844						**1844**	**1844**	**1844**	**1844**
1845		**1845**		**1845**						1845		1845	1845
1846		**1846**		**1846**	1846					1846		**1846**	
1847											1847	1847	1847
													1848
1849										1849			1849
		1850			1850					1850	1850		1850
		1851			1851						1851		
					1852								
		1853											
1854		1854											1854
										1857			
											1861	1861	
													1862
													1863
			1866	1866						1866			
											1870		
1871	1871	1871		1871	1871	1871		1871	1871	1871	**1871**	**1871**	**1871**
	1872	1872		1872	1872	1872		1872		1872	**1872**	**1872**	**1872**
	1873		1873	1873	1873	1873					**1873**	1873	
		1874		1874						1874			1874
										1875		1875	
		1876		1876	**1876**			1876		1876	1876		**1876**
1877		**1877**						1877		**1877**	**1877**	**1877**	**1877**
1878								1878		1878		1878	1878
1879		1879	1879	1879	1879	1879		1879		1879	1879	1879	1879
1880	1880	1880		1880						1880		1880	1880
	1881	1881								1881	1881	1881	
1882	1882	1882		1882	1882		1882	1882	1882	1882	1882		1882

* Appeared west of

Fly years, so far as recorded.

Wisconsin.	Iowa.	Minnesota.	Georgia.	Tennessee.	Kentucky.	Missouri.	Arkansas.	Kansas.	Nebraska.	Texas.	Massachusetts.	Vermont.	Maine.	Canada.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	1779	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	1805
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	1816
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1829	1823	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	1835	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1844	1844	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	1845	...	...	...	...	...	...	...	...	...	...	...
1846	1846	...	1846	...	...	...	...	...	...	...	...	...	...	1846
1847	...	...	...	...	...	...	...	...	...	...	...	...	...	1847
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1850	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	1852	1852	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	1854	...	...	...	...	...	...	...	...	...	...	...	1854	...
...	1860	1860	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	1867	...	...	...	...	...
...	...	...	...	1868	...	...	...	...	...	...	...	...	...	...
...	...	...	...	1869	...	1869	...	...	1869	...	...	...	...	...
...	...	...	...	1870	1870	1870	...	...	...	...	...	...	...	...
...	...	1871	1871	1871	1871	**1871**	...	1871	...	...	...	...	...	...
...	...	...	...	1872	...	1872	1872	1872	1872	...	...	...	...	...
...	...	...	...	...	1873	1873	...	...	...	...	...	...	...	1873
...	...	...	...	1874	...	1874	1874	...	1874	...	...	...	...	...
...	...	...	...	1875	...	1875	...	...	...	...	...	...	...	...
1876	1876	**1876**	**1876**	**1876**	...	**1876**	1876	**1876**	1876	**1876**	**1876**	...	...	...
...	...	...	...	1877	...	**1877**	...	...	...	...	...	...	...	...
...	...	...	...	**1878**	...	1878	...	...	...	...	...	...	...	...
...	1879	...	...	1879	1879	...	...	1879	...	...	...	...	...	...
1880	...	...	...	1880	1880	1880	...	...	...	1880	...	...	...	...
...	1881	1881	1881	1881	...	1881	...	...	1881	...	...	...	...	...
1882	...	...	1882	1882	...	...	...	...	...	...	...	...	...	1882

Alleghany Mountains.

DISTRIBUTION OF THE HESSIAN FLY.

There seems to be good reasons for believing that this insect was introduced from southern and southeastern Europe. It was detected there in the spring of 1834, by Prof. J. D. Dana, who found the larvæ and pupæ, and reared the flies from wheat growing on the island of Minorca. He sent several pupæ and flies from Mahon to Mr. Herrick, who identified them as the Hessian Fly.[113]

With Herrick, Fitch, and others, when we prepared our Bulletin on this insect, we were disposed to credit the prevalent belief of Colonel Morgan, that this fly was introduced into America in the straw supposed to have been used for packing, brought by the Hessian troops during the Revolutionary War, in August, 1776. It was supposed that the starting point from which the fly originated was the western end of Long Island, and that it spread from that point over different parts of the country.

Our republication of the view that this fly was introduced by the Hessians led to the publication of an article by Dr. H. A. Hagen in the *Canadian Entomologist* for October, 1880, wherein he states that Dr. B. Wagner, of Fulda, Hesse Cassel, had some years since disproved the theory that the Hessian troops could have introduced the insect from Germany. This led us to obtain Wagner's publication, a translation of which, with Dr. Hagen's paper, and other articles by Loew, Cohn, and Köppen, we reproduce wholly or in part in the appendices to this report in order that the reader may have all the known facts regarding the appearance and distribution of the Hessian Fly in Europe.

From Dr. H. Loew's paper, published in 1859, it appears that a new enemy of the rye, called the New Corn Worm or Rye Maggot, made its appearance in certain districts of the provinces of Silesia, Posen, and Prussia, in 1857 and 1858. This insect he called *Cecidomyia secalina*, supposing it, from want of specimens for comparison, to be different from *C. destructor*. It was afterwards shown by Dr. Wagner and Professor Cohn to be the same as the so-called Hessian Fly.

Dr. B. Wagner, whose essay is carefully prepared and evidently re-

[113] Mr. Herrick, in his valuable article in *Silliman's Journal* (vol. xli, p. 154), informs us that Mr. J. D. Dana, who had been much associated with him in making a thorough investigation of the habits of the Hessian Fly and its parasites, being on a voyage in the Mediterranean, "on the 13th of March, 1834, and subsequently, collected several larvæ and pupæ from wheat plants growing in a field on the island of Minorca. From these pupæ were evolved, on the 16th of March, 1834, two individuals of an insect, which his recollections (aided by a drawing of the Hessian Fly with which he was provided) enabled him to pronounce to be the *Cecidomyia destructor*. More of the perfect insects were evolved in the course of the month, one of which deposited eggs like those of the Hessian Fly. In letters dated Mahon, April 8 and 21, Mr. D. sent me five of the insects and several of the pupæ. They arrived in safety, and, after a careful examination, I saw no good reason to doubt the identity of this insect with the Hessian Fly. The Mahonese asserted that the insect had been there from time immemorial, and often did great damage both there and in Spain." And further, "on the 28th of April, 1834, Mr. D. collected from a wheat-field just without the walls of Toulon, in France, several pupæ and one larva like those before obtained. On the 4th of June, 1834, he obtained similar pupæ from a wheat-field near Naples." We doubt whether there were living at that day, two persons better qualified to determine the identity of these insects with the Hessian Fly than Messrs. Herrick and Dana. Testimony from such a source needs no comment. "The Hessian Fly." By Asa Fitch, pp. 5, 6.

liable, effectually disproves the theory that the Hessian troops could have carried the fly to America.

In the first place Wagner shows that the habits and characters of Loew's Rye Maggot agree "even in the most minute details" with his observations on *C. destructor*, which occurred at Fulda, in Hesse Cassel, in the spring of 1860. Then, after referring to Dana's observations of the insect on the Mediterranean coast, he confidently expresses the opinion that Loew's Rye Gall-Fly is identical with the Hessian Fly, with which the species from Southern Europe agrees—*i. e.*, the German, southern European and North American species are altogether nothing but *Cecidomyia destructor*. Wagner then discusses from historical data the question as to the introduction of the insect into America by Hessian troops, and the historical facts seem to warrant his opinion, that the packing straw used by the Hessians was grown the year previous, and from the long time occupied in the passage of the English transports, which left Germany in March and April, not arriving until August, the flies must have all emerged from the wheat before the end of the spring and have perished long before the troops reached America. Moreover, Wagner shows that *Cecidomyia destructor* was not known in any part of Kurhesse before 1857, records running back for eighty years containing no notice of the occurrence of such an insect. Hence he claims that this insect was not originally a Hessian Fly; that this name should be dropped, and the name "wheat destroyer" should be substituted for it.

Having denied that this fly is indigenous in Hesse (and for that matter in Germany), he suggests that it was, like some other insects, introduced into Germany from southern Europe, and that as wheat was "distributed from the Orient over southern Europe," *Cecidomyia destructor* may have been of eastern origin. He then quotes Loew's statement "that a Cecidomyia, which in its manner of life and metamorphosis cannot be distinguished from *C. destructor*, does great injury to the wheat crops on the south shore of Asia Minor," and adds that this fact favors the assumption of its eastern origin.

Wagner then remarks:

When and from what shore the insect came to America can never be accurately determined. Probably it was introduced several times and at different times. That it happened from the shore of an European state previously possessing colonies in North America must be accepted. It cannot have occurred from England, when Banks reported its *non-occurrence* in *all* parts of Europe; this may apply to England. Holland and Belgium we may justly omit. On the other hand, not only the long existing occurrence of the insect in southern France speaks for the introduction from the French coast to the once so extended possessions of the French in North America, but also the comparatively short distance, which facilitated the introduction of infected straw, thus enabling the insect to issue after arriving.

Wagner then quotes the statement made by Fitch, which we will quote direct from Fitch himself, as follows:

We have nowhere met with but one statement, which goes directly to prove that the insect is indigenous to this country, or existed here anterior to the arrival of the

Hessian troops. The late Judge Hickock, of Lansingburgh, N. Y.,[114] in a communication to the Board of Agriculture in the year 1823, and published in their *Memoirs* (vol. ii, p. 169), says, "A respectable and observing farmer of this town, Col. James Brookings, has informed me, that on his first hearing of the alarm on Long Island, in the year 1786 (doubtless 1776 is intended), and many years before its ravages were complained of in this part of the country, he detected the same insect, upon examining the wheat growing on his farm in this town.

Wagner then adds that he will not deny the possibility that, as Fitch presumes, the insect observed by Colonel Brookings was not the Hessian Fly, but he adds that the attacks of the latter are highly characteristic, and in their consequences so conspicuous, that a mistake concerning the insect could happen only during its first appearance in a locality. "In our country [Hesse-Cassel], for instance, after but one year's experience, every farmer knows the pseudo-pupæ of this enemy; he knows exactly how they look, when they occur on the stalk, &c."

It may also here be stated that Dr. Mitchell, in his article in the Encyclopædia Britannica, says, "It was first discovered in the year 1776." Dr. Hagen's statement would leave the reader to infer that Dr. Mitchell had stated that the fly had appeared in 1776, "before the arrival of the troops," but the words in quotation marks are simply Dr. Hagen's own words. We have not seen the edition of the Encyclopædia Britannica containing Mitchell's article. What Mitchell did say in substance was that the Hessian Fly appeared in 1776. Whether before or after the landing of the Hessian troops he does not say. So the evidence of Dr. Mitchell is not of much value, while that of Colonel Brookings is quite explicit, and may be used as proof of the appearance of the Hessian Fly in 1776 in Lansingburgh, N. Y., and that the Hessian troops had nothing to do with its importation.

Dr. Hagen, who adopts Wagner's opinion that the Hessian Fly was not imported by the Hessians, and whose article is based mainly on Wagner's publication, which we may here say was unknown to us until he called attention to it, also confirms Wagner's statement that the Hessian Fly was unknown in Prussia, and indeed in Germany, until 1857. He states also that "in 1859 the same insect was very obnoxious to the rye in Eastern Prussia, and was studied by myself. In 1860 it had advanced westward to Augsburg, where it was studied by Professor Rosenhauer, and to Fulda, Hesse. Everywhere it was considered to be an entirely new pest, never seen or observed before. * * * In the following years the calamity subsided, and was soon nearly forgotten. Extensive destructions in Hungary in 1864 are reported by Messrs. Haberlandt and Kuenstler, and in 1879 in Russia. I find no statements of injury done by the fly in Germany after 1860, and the reports for Bohemia for 1872 and 1879 state directly that the fly was not observed. Dr. Schiner, in Vienna, had till 1864 seen no specimen; the best proof that it had not been obnoxious in Austria."

---

[114] Near Troy, in Rensselaer County.

On the same page of this article Dr. Hagen remarks as follows:

Mr. V. von Motschulsky describes in 1852 a fly very obnoxious to the wheat in the governments of Saraton and Simbirek, in Rusland [Russia], as *C. funesta*, together with its parasites. I may add that von Motschulsky, after his return from America, and having received typical specimens of the Hessian fly and its parasites from Dr. A. Fitch, has assured me that *C. funesta* and *C. destructor* are the same species. This is also accepted in von Osten Sacken's catalogue.

In the appendix we present a translation of Professor Cohn's researches on the injuries committed by the Hessian Fly in the summer of 1869 in Silesia.

Desirous of obtaining specimens of and information concerning the European insect, we wrote to several entomologists in Germany and Austria. From Prof. Ferdinand Cohn, of the University of Breslau, we received the following obliging letter, which throws much light upon the subject. The specimens he sent us were duly received. On comparing the ten German puparia with numerous specimens from the Middle States we can find absolutely no varietal difference between them, either in the form of the segments or in the form of the puparium at either end. We have not up to the time of reading proofs of these pages again heard from Professor Cohn; and careful comparisons between the European and American examples of the larva, pupa, and imago of the *Cecidomyia destructor* have yet to be made.

The following is a copy verbatim of Professor Cohn's letter which was written in English:

BRESLAU, *February* 28, 1882.

DEAR SIR: I regret that I am not more in the possession of specimens of the Cecidomyia which I did mention in my Untersuchungen über Insektenschaden in 1869. If my memory does not deceive me, I sent the fly to Professor Loew, with whom I was corresponding in that time about the matter. The only specimen of an injured wheatstalk I can find in my collections contains also a puparium, and I beg to send it to you in the accompanying parcel. In the same box I inclose the only remains of the female fly which I still possess,[115] the rest being destroyed by Psocus. In 1880 I had opportunity to study a second time the damages of this fly. A seed-merchant in a district not far from Breslau (Jrebnitzer Kreis) had sold to the farmers seed of English wheat (Wechselweizen) which is believed to grow with equal ease as summer or as winter corn. The farmers had sown the seed in autumn, 1879, but in the following spring the wheat had grown sick and did not produce ears. April, 1880, from the 15th to the 23d, had been extraordinarily warm; on the 24th April the thermometer began to fall; the end of April to the midst of May were cool; from 14th to 16th May few mild and sunny days; then a series of very rough and unusually cold days followed (17th–25th of May); on the 20th frost, which did injure the fields in whole Silesia. Summer wheat had not been injured by this weather; I found the fields of that variety in the first days of August in the finest growth. But the English Wechselweizen sown in autumn, 1879, had shown the most manifest sickness, the shoots being very numerous, but low, yellow, and without or very rarely producing ears. Nearly in all the shoots I found on the bottom of the stalks the larvæ of the pupæ or that Cecidomyia which I believe to be *C. destructor* or Hessian fly; larvæ were found still in the beginning of August.

The enormous damage in that country is due, I believe, to the Hessian fly, the eggs of which had been deposited in autumn, 1879, upon the young crop. The first generation of flies had swarmed out, I suppose, in the second half of April, favored by the

[115] Is not practicable. [This was therefore not sent.—A. S. P., jr.]

extraordinary warmth of that period; the cold May had retarded the growth of the crop, so that the larvæ of the second generation growing in the young stalks did totally destroy the germs of the ears; had the spring been warmer, the shoots would have grown out the damages of the fly; now most part of the sprouts had been killed. That at least is the explanation I may give to the facts.

I collected some pupæ in the wheat field on 3d of August, which I put in a small glass; but none crept out, some being killed by fungi and some by Pteromalinæ.[116] Nevertheless, I send you the glass. I fear the communication I send you to-day will not suffice for the determination of the species; next summer I shall attend to the matter, and I hope to be able to send you fresh specimens, which may suffice to decide the question.

Meanwhile I remain, yours very respectfully,

FERDINAND COHN.

It will also be seen by the translation of Köppen's article (see appendix) that in 1879 and 1880 *Cecidomyia destructor* was "distributed over a great part of middle and Southern Russia," and it seems probable from his statement that as early as 1852 it was abundant in the district of Charkow.

From all the information we have before us, and in the light of Wagner's investigations, we are strongly disposed to believe:

1. That the Hessian Fly had appeared in the eastern United States before the Revolutionary war, and that it could not have been introduced by the Hessians.

2. That the Hessian Fly has never been known to inhabit England or northern Europe.

3. That it was not known in Germany before 1857.

4. That it has "from time immemorial" been an inhabitant of wheat fields on the shores of the Mediterranean, in Spain, at Toulon in France, at Naples, in Minorca, and Asia Minor.

5. That it probably originated in this region or farther east, the probable original habitat of the wheat and other cereals.

6. That it was introduced from southern Europe, either southern France or other Mediterranean regions, perhaps Asia Minor, before the Revolutionary war.

That the *Cecidomyia destructor* originated in southern Europe and western Asia, *i. e.*, about the shores of the Mediterranean Sea, seems most probable from the statements of Herrick and Dana which we have quoted. From this region it has possibly spread into Germany; and from Asia Minor and perhaps southern Russia it has probably spread into central Russia.

We are, then, disposed to adhere to Wagner's conclusions that the insect could not possibly have been indigenous in Germany; and we are therefore unable to agree with Dr. Hagen that the Hessian Fly is "an indigenous American insect," and that it "was indigenous here as well as in the Old World."

[116] Professor Riley has submitted specimens to Mr. L. O. Howard, who writes us as follows: "The European Hessian fly parasite received from Professor Cohn is a Platygaster, but as this genus has not been worked up systematically in Europe, and as there are scores of isolated descriptions, it is practically impossible to determine it specifically."

It seems to us that the fact that the fly has never been known to occur in England, Scandinavia, Holland or Belgium, and the fact that it most probably was introduced into Germany and central Russia from the southward, *i. e.*, the Mediterranean region, shows that the fly was not originally a member of the entomological fauna of northern and central Europe. Had the Hessian Fly been indigenous to the Middle and New England States, and been at all prevalent before the Revolutionary war, it would undoubtedly have been carried in loads of wheat to England. A search through the files of old Philadelphia papers in the National Library at Washington, while it failed to reveal any data regarding the presence of the Hessian Fly in the colonies before 1776, and no articles were found other than those already cited by Dr. Fitch,[117] yet elicited one interesting fact, *i. e.*, that wheat was raised in Canada and the American colonies and exported to England, especially the port of London. Grain vessels loaded at Quebec, and also from New England, for London[118] and other ports.

Now if the Hessian Fly had been indigenous many years before 1776, in the wheat-fields of this country, some at least would probably have been carried in loads of grain to England. On the other hand if the Hessian Fly had been indigenous in England and northern Europe, it would doubtless have been brought over to this country some years before the American Revolution. On the other hand it may have been imported into the French colonies in Canada from southern France, by immigrants. Whether there ever was much of a trade between the Mediterranean ports and Canada before the Revolutionary war we cannot say. But it would seem most probable that the Hessian Fly was an inhabitant originally of a warm and dry country, like that of the Mediterranean region. We know that the *Cecidomyia destructor* does not inhabit England or Scandinavia. In New England, north of Connecticut, it is not common, and has only occasionally been locally destructive. Its ravages have been confined to the Middle and Western States, and western Canada. A comparison of the history of the Hessian Fly with that of the Wheat Midge, *Diplosis tritici*, which as everybody knows is common in England and throughout northern Europe, and was undoubtedly imported into this country, will throw light on this subject.

---

[117] The writer has made an attempt to find some mention of the Hessian Fly in old colonial newspapers published before 1779, but the files of the Philadelphia Packet and of the Mercury in the National Library, which are imperfect, disclosed nothing that Fitch does not quote. There are no full files of colonial papers in the Boston and Cambridge libraries, and it is probable that unless in the State Library of New York, at Albany, there can no records be found of the Hessian Fly, other than those referred to by Dr. Fitch.

[118] "On Friday last arrived in the river [London] from Quebec, the Active, Trampton, with a cargo of wheat, being the first vessel that ever came to London from that port with grain. London, October 18."—*From the Pennsylvania Packet, December* 27, 1773.

In the Philadelphia Mercury, for October 7, 1775, it is stated that "great quantities of wheat were raised at Genoa, Leghorn, and on the Mediterranean. * * * This year there was one of the most plentiful harvests in Italy ever known."

The ports of London, Bristol, and Liverpool, as well as every other port in England, have received immense supplies [of wheat] from America, much more than their consumption can take care of.—Extracts from a letter dated October 7, 1775, from an eminent house in Lisbon.—*Philadelphia Mercury*, December 22, 1775.

As stated by Drs. Harris and Fitch, the Wheat Midge was abundant and widespread in England several years previous to 1771; it was common in Scotland and Ireland, and according to Herpin it abounded in France. It is undoubtedly a native of northern Europe, and adapted to a cool and moist climate. There is every reason to suppose that the *Diplosis tritici* was not a native of this country, but was imported in the beginning of this century from Great Britain into either Canada or New England. Harris states that it first appeared in this country in western Vermont, in 1820; by 1828, it had attracted notice in northern Vermont, and on the borders of Lower Canada; from these places it overran New England, New Brunswick, and Nova Scotia, also extending west. It has from the year 1834 been the chief wheat pest in the cooler portions of Maine, flourishing where the Hessian Fly is comparatively or wholly unknown.

It seems to us that the history of the two insects shows quite conclusively that both are European importations; the Wheat Midge from northern Europe, and the Hessian Fly an earlier importation from the Mediterranean wheat fields, and which flourishes therefore better in the warmer regions of the United States than the Wheat Midge, a native of northern Europe.

ITS DISTRIBUTION IN NORTH AMERICA.

Introduced, then, by causes unknown, into New York and Long Island, the Hessian Fly gradually spread over the wheat area of the colonies, and afterwards of the United States, enlarging its limits of distribution with the corresponding increase in the extent of the wheat area of our country.

It spread more rapidly at first towards the eastward, nearly to the end of Long Island and to Shelter Island. As Havens remarks, "It was first perceived a little before harvest, and appeared to have come from the west end of Long Island in a gradual progress of between twenty and thirty miles a year."

In ten years after its first recorded appearance in America it reached Prospect, N. J., about forty miles southwest of Staten Island, and in 1788 it was noticed at Trenton, N. J., and in Pennsylvania. Undoubtedly, had there been railroads at that time, with the rapid transit of grain-cars and bales of hay and straw, it would have spread at least with three times the rapidity of its recorded rate of diffusion.

In 1789 the fly first reached Saratoga, a point situated 200 miles north of its original point of departure. "The insect reached here by a regular progress from the south, coming nearer and nearer each successive year."

It appeared west of the Alleghanies in 1797, though in what State we are unable to learn; while Virginia was invaded in 1801, and North Carolina about the year 1840. Westward its progress brought it to Ohio in 1840, and three years later it was detected in Michigan. In

1844 it was destructive in Ohio, Indiana, Illinois, Michigan, Wisconsin, and the eastern border of Iowa; while it was common in the Middle Atlantic States, and became destructive in northern Georgia in 1845. Meanwhile it had reached western Canada in 1805. North of Connecticut it seems to have existed only sporadically, and to have maintained only a temporary foothold in Vermont and Maine in 1850–'52, and has never been noticed by authors in New Hampshire or in Massachusetts.[119] Minnesota was visited in 1860, and probably earlier. In Beverly, Mass., it was common in wheat fields in 1877.

It must have reached Missouri, Arkansas, and Texas long previous to the date given in our table, but probably the year it entered eastern Kansas (1871–'72) is not much posterior to its arrival there, at present its westernmost limit.

The following facts regarding the occurrence and distribution of the Hessian Fly have been obtained since the publication of the original Bulletin. The map appended to this report will show its present range in the United States and Canada:

THE HESSIAN FLY IN MAINE.

The only authentic information we have been able to gather as to the occurrence of this insect in Maine is what we learned from Mr. William Alexander, of North Harpswell, Me., who told us that on his farm (then his father's) between forty and fifty years ago, in one spring the spring wheat sown from the 10th to the 15th of April was affected by a maggot between the leaf and the stalk, which caused the young wheat to turn yellow.

THE HESSIAN FLY IN MASSACHUSETTS.

Neither Dr. Harris nor any other entomologist has noticed in print the occurrence of *C. destructor* in this State. It has probably occurred there in limited numbers since 1859, when it was observed in Danvers, by Rev. John L. Russel, who pointed it out to Mr. John Lears in June, 1859. Mr. Lears has seen it in wheat occasionally since then. In or about the year 1877, specimens of wheat, at least a foot high and containing the puparia, were brought to me, June 10, from Beverly, Mass.

THE HESSIAN FLY IN VERMONT.

The *Vermont Chronicle* for 1829 records the occurrence of this insect.

THE HESSIAN FLY IN NEW YORK.

It appeared in Washington County in 1830.—[*Salem* (N. Y.) *Post.*

[119] Sir Joseph Banks drew up a report on this insect for the Privy Council, dated March 12, 1789. He states that "since its first appearance in Long Island it has advanced at the rate of fifteen or twenty miles a year, and neither waters nor mountains have impeded its progress. It was seen crossing the Delaware like a cloud from the Falls Township to Wakefield; had reached Saratoga, 200 miles from its first appearance, infesting the counties of Middlesex, Somerset, Huntington, Morris, Sussex, the neighborhood of Philadelphia, all the wheat counties of Connecticut, &c., committing the most dreadful ravages, attacking wheat, rye, barley, and timothy grass. The Americans who have suffered by this insect speak of it in terms of the greatest horror."—Dobson's Encyclopedia, viii, art. Hessian Fly.

THE HESSIAN FLY IN MARYLAND.

It appeared in Maryland in 1830.—[*Easton Gazette.*

THE HESSIAN FLY IN NORTH CAROLINA.

The Hessian Fly occasionally does considerable damage in Burke County.—[H. K. Morrison.

Prof. F. W. Simonds, University of North Carolina, writes us (January 12, 1881) that he cannot learn that the Hessian Fly is in the neighborhood of Chapel Hill.

THE HESSIAN FLY IN MICHIGAN.

GALESBURG, MICH., *December* 1, 1880.

DEAR SIR: Your note of the 24th of November is just at hand. I have a few larvæ and pupæ of the Hessian Fly in alcohol, taken last year, which I will send. Will send living ones in the plant as soon as occasion offers. At present the ground is covered with a foot of snow. During the past season the fly has done no appreciable damage in this portion of the State. Hardly any of the larvæ and pupæ were to be found in the wheat sown this fall, though in fields where the ground had been plowed to stubble in wheat, and wheat had come up in August, I found some of the larvæ, but not in abundance. I have neither seen the parasite *Semiotellus destructor* nor any indication of its presence in the larvæ of the fly. During the summer I have discovered a new—to me—insect at work in the wheat, which is nearly allied to the Hessian Fly. Owing to its being a very busy season I did not even rear the insect to the perfect imago, and only observed it in the larva and pupa state. Have regretted that I did not *take* more time to attend to it. I should judge that the fly deposited the eggs near the base of the stem, and that the insect, on hatching, worked into the stem to the center of the plant, and then upward through the third or fourth joint, living upon the juices in its progress, and when almost fully grown eating through the stem just above the joint; then fixing itself in the sheath, as does the Hessian Fly, to the lower joint, it undergoes gradually the change to the chrysalis. These are of a *deep* chestnut color about three-fourths the size of those of the Hessian Fly, and not more than three of the insects were found by me in one stalk. The stem of the plant, being weakened by the insect, breaks off just above the joint, and *below* the spot where the pupa is, just before the heads mature, usually, though some heads were partly filled with small, defective kernels. The insect seems to confine its operations to red wheat, and the Fultz variety was this season damaged the most. I did not find a single one on the Clawson wheat, while some fields of Fultz wheat had about one-fourth of the stalks damaged.

Very truly yours,

F. S. SLEEPER.

A. S. PACKARD, Jr.

The fly has made sad havoc in the wheat-fields of southwestern Michigan. Fields that looked fine a few weeks ago are fully one-half destroyed.—[*Providence Journal*, December 6, 1881.

GALESBURG, MICH., *December* 20, 1881.

DEAR SIR: Your note of the 20th of September was duly received, requesting me to collect the eggs of the Hessian Fly, with a view to obtaining egg parasites of the fly. I have been very busy this fall, and could not give it the time when it ought to have been given. Yet on several occasions I have spent some time, and, with the most diligent search, have seen the fly only on one afternoon, and then in few numbers, and have failed to find *any* of the pupa or flaxseed. What is the reason for the scarcity I do not know. We have had a very unusual season, long droughts alternating with excessive rainfalls. Will try in the future to comply with your request.

Truly yours,

FRANK S. SLEEPER.

A. S. PACKARD, JR.

THE HESSIAN FLY IN TENNESSEE.

CHARLOTTE, TENN., *November* 1, 1879.

DEAR SIR: The following are the answers, as far as I am able to give them, to the questions in your circular No. 8, United States Entomological Commission:

Question No. 1. Don't know; have no information.

Question No. 2. The fly appears in October and November in the fall, and in April and May in spring.

Question No. 3. The fly has been known here for a long time; in 1878 it did great damage; don't know how it was introduced.

Question No. 4. Don't know how many broods or generations are observed annually. The plants are dwarfed in the fall, and fail to produce grain at harvest.

Question No. 5. The Mediterranean, Red Chaff, Red May are less liable to be damaged by the fly than any we have tried; don't know in what other cereals or grasses the insect is known to develop.

Question No. 6. Warm, dry fall favors its injuries. Seasonable weather in the fall and a vigorous growth prevent the fly.

Question No. 7. I know nothing as to this question; the last crop was clear of the fly. Have made no experiments.

Question No. 8. I have no data by which to answer this question.

Question No. 9. The best preventive found here is to pasture the wheat close in the winter with sheep. Burning the débris on the ground in the fall is also resorted to, and does good. I have no specimens of wheat affected by the maggots.

Respectfully,

ROBERT McNEILLY,
Charlotte, Dickson County, Tennessee.

A. S. PACKARD, JR.

1. In April and May.
2. In early autumn, at and before seeding and warm weather; in winter and early spring.
3. About 55 or 60 years since was heard of in New England before appearance here, and is supposed to come from that direction.
4. Eggs are deposited soon after wheat is up, and thereafter as the weather is mild and not wet. Damage not strikingly manifest until spring and early after.
5. It is not clear that any variety is less likely to suffer injury than others. No other cereals or any grasses are known to be subjects of its depredations.
6. Dry, warm weather favors its injuries; frosts (before which it is not safe to sow) check the egg deposits, and heavy freezes retard their development.
7. None troubled my crop this season, and I could make no examinations.
8. I hear of neighborhoods where the loss from fly is estimated at 25 per cent. Their attacks are not at all general, and some years not any whatever. Their injuries are less frequent of late years, and not so all-pervading as they were many years in the past.
9. Some contend that grazing with sheep destroys the eggs, but the fancy is not as convincing as that the wheat receives a greater injury. Sowing at or near frosts is the only preventive that has general acceptation.

Very respectfully,

EPH'M LINK,
Greenville, Greene County, Tennessee.

THE HESSIAN FLY IN NEBRASKA.

WEST POINT, NEBR., *February* 23, 1881.

I will now send you what data I have thus far been able to gather relative to the Hessian Fly (*Cecidomyia destructor*) in Nebraska.

Individually I have seen but few of the fly.

The greater number of notices of their existence in the State are based on Professor Aughey's notes of specimens received for identification from time to time.

Prior to 1867 the Hessian Fly seems to have been absent from Nebraska, but during this year specimens were received from Cass and Otoe Counties, where they were noticed in wheat-fields doing some damage to some of the stalks. They were few in number and only in isolated spots in some fields. The following year they had become more general in these two counties, but not in sufficient numbers to cause uneasiness. In 1869 they had spread into Sarpy and Douglas Counties. 1872 extended their range into Lancaster, Seward, and Saunders Counties. They were also sent from York County this year, where they were taken in a field of winter wheat. Both eggs and larvæ were sent.

During 1873 they did not seem to spread to any great extent; but in 1874 they made their appearance in Pawnee, Gage, and Richardson Counties. In 1876 they were received from various counties in southeastern Nebraska, where they did some damage in isolated localities, but not of sufficient note to cause alarm. Since that time they have been regularly received each year from various portions of eastern Nebraska. Of these no notes have been kept, but it is known that they have been spreading, and if not soon checked will cause not a little uneasiness among grain-growers.

LAWRENCE BRUNER.

MAY 23, 1881.

Some time ago you requested me to continue my investigations with reference to the Hessian Fly and report. Well, I have been over a considerable portion of the country bordering the Missouri River north of the Platte since grain is up, and have also made inquiries with reference to various sections south. Thus far but *few* of the flies are reported—the only substantial record being near Lincoln by Professor Aughey. He was out collecting a few Coleoptera and saw several dozen stalks of wheat suffering from its attacks. No other locality, as far as I am aware at present, has been visited this season. Of course it can hardly be doubted but that a few of last year's stock of flies withstood the rigors of the past winter; and it is my opinion that by careful search a few might be found throughout the entire area ravaged by them last season. (I do not mean by this that this insect was at all destructive the past year, but that it was present and did some damage.) But to make this sort of observations would require some little time and cause some expense; hence, no particular person desires to take it upon himself to do so.

I have interviewed Professor Aughey in reference to causes of its seeming scarcity, and he thinks that the ice and snow which remained on the ground the entire winter have had something to do with it.

LAWRENCE BRUNER.

SUMMARY OF THE HABITS OF AND REMEDIES AGAINST THE HESSIAN FLY.

1. There are two broods of the fly, the first laying their eggs on the leaves of the young wheat from early April till the end of May, the time varying with the latitude and weather; the second brood appearing during August and the early part of September, and laying about thirty eggs on the leaves of the young winter wheat.

2. The eggs hatch in about four days after they are laid. Several of the maggots or larvæ make their way down to the sheathing base of the leaf, and remain between the base of the leaves and the stem near the roots, causing the stalk to swell and the plant to turn yellow and die. By the end of November, or from thirty to forty days after the wheat is

sown, they assume the "flaxseed" state, and may, on removing the lower leaves, be found as little brown, oval, cylindrical, smooth bodies, a little smaller than grains of rice. They remain in the wheat until during warm weather; in April the larva rapidly transforms into the pupa within its flaxseed skin, the fly emerging from the flaxseed case about the end of April. The eggs laid by this first or spring brood of flies soon hatch; the second brood of maggots live but a few weeks, the flaxseed state is soon undergone, and the autumn or second brood of flies appear in August. (In some cases there may be two autumn broods, the earliest August brood giving rise to a third set of flies in September.)

3. There are several destructive ichneumon parasites of the Hessian Fly, whose combined attacks are supposed at times to destroy about nine-tenths of all the flies hatched. Of these, the most important is the Chalcid four-winged fly (*Semiotellus destructor*, Plate IV, fig. i, much enlarged), which infests the flaxseed; and and the small parasite (Platygaster, Fig. 9, p. 219, *ante*).

4. By sowing a part of the wheat early, and, if affected by the fly, plowing and sowing the rest after September 20, the wheat crop may in most cases be saved. It should be remembered that the *first* brood should be thus circumvented or destroyed in order that a second, or spring, brood may not appear.

5. If the wheat be only partially affected, it may be saved by fertilizers and careful cultivation; or a badly-damaged field of winter wheat may thus be recuperated in the spring.

6. Pasturing with sheep, and consequent close cropping of the winter wheat in November and early December, may cause many of the eggs, larvæ, and flaxseeds to be destroyed; also, rolling the ground may have nearly the same effect.

7. Sowing hardy varieties. The Underhill Mediterranean wheat, and especially the Lancaster variety, which tillers vigorously, should be sown in preference to the slighter, less vigorous kinds in a region much infested by the fly. The early (August) sown wheat might be Diehl; the late sown, Lancaster or Clawson.

8. Of special remedies, the use of lime, soot, or salt may be recommended, also raking off the stubble; but too close cutting of the wheat and burning the stubble are of doubtful use, as this destroys the useful parasites as well as the flies.

LIST OF WORKS AND ARTICLES RELATING TO THE HESSIAN FLY.

The following list embraces the most important writings relating to the Hessian Fly. The titles of many of them are taken from Fitch's report and the bibliographical list in Bergenstamm and Loew's *Synopsis Cecidomyidarum:*

DUHAMEL. Éléments d'Agriculture. Par Duhamel du Monceau. Paris, 1771, i, p. 229.

MORGAN, GEORGE. Pennsylvania Mercury, June 8, Sept. 14, 1787.

CLARK, THOMAS. Pennsylvania Mercury, Sept. 14, 1787.

VAUX and JACOBS. Philadelphia Packet, Aug. 21, 1788.

HAVENS. Observations on the Hessian Fly. By Jonathan N. Havens. Transactions of the New York Society for the Promotion of Agriculture, Arts, and Manufactures, 1792. Second edition, 1801, pp. 71–86.

CHAPMAN, Dr. ISAAC. Memoirs of the Philadelphia Society for Promoting Agriculture, v, 1797.

ENCYCLOPÆDIA BRITANNICA, viii. Article Hessian Fly, pp. 489–495, 1797.

DOBSON. Encyclopædia; or a Dictionary of Arts and Sciences and Miscellaneous Literature. Article Hessian Fly. Published by Thomas Dobson. 21 vols. Philadelphia, 1798–1803, viii, pp. 489–495, 1798.

MITCHELL. Encyclopædia Britannica. Address in Transactions of the New York Society of Agriculture, i, p. 32. Article in Medical Repository, vii, p. 97, 1803.

ANONYMOUS. Carey's American Museum, Phila., i, pp. 143, 324–326, 1786; iv, p. 47, 1788; xi, pp. 285, 301, 1792.

McLELLAN. Article in American Farmer, by H. McLellan, ii, p. 234, 1804.

KIRBY and SPENCE. An introduction to Entomology, by W. Kirby and W. Spence. 1815–'26, i, p. 50.

BOSC. Quelques apperçus sur l'insecte connu sous le nom de Mouche Hessoise, et sur un insecte parasite qui s'en nourrit. Par L. A. G. Bosc d'Antic. Annales de l'Agricult., France. Tom. 70, pp. 277–303, 1817.

SAY. Some account of the insect known by the name of Hessian Fly, and of a parasitic insect that feeds on it. By Thomas Say. Journal of the Academy of Natural Sciences, i, pp. 45–48, with a plate, 1817. See also Magazine of Natural History, vol. i (Kirby).

ACKERLY. An account of the wheat insect of America, or the *Tipula vaginalis tritici*, commonly called the Hessian Fly. By Samuel Ackerly. American Monthly Magazine and Critical Review, New York, i, pp. 275–279, August, 1817.

COCKE. Address by John H. Cocke to Albemarle Agricultural Society of Virginia, 1817.

MERRIWEATHER. Articles, by Dr. Merriweather and others, in the Richmond Inquirer, National Intelligencer, and American Farmer, 1817 *et seq.*

GARNETT. Article by James M. Garnett in the American Farmer, ii, p. 174, 1820.

TILGHMAN. Article by Edward Tilghman in the American Farmer, ii, p. 235, 1820. Also in Cultivator, viii, p. 82, May, 1841.

WORTH. Article by James Worth in American Farmer, ii, p. 180, 1820.

HICKOK. Essay by Judge Hickok in Memoirs of the New York Board of Agriculture, pp. 169–171, 1823.

BIRNIE. On the efficacy of certain steps to preserve wheat from the fly and smut (Hessian Fly). By C. Birnie. New England Farmer, iii, p. 171, 1824.

BUEL. Paper by Judge Buel in the Memoirs of the New York Board of Agriculture, iii, pp. 326–338, 1826.

WESTWOOD. Article Cecidomyia, by J. O. Westwood, in British Cyclopædia of Natural History.

KOLLAR. Naturgeschichte der schädlichen Insecten in Bezug auf Landwirthschaft und Forstkultur. Wien, 1837. English translation by J. and M. London, with notes by J. O. Westwood. London, 1840, pp. 118–123.

MORRIS. On the *Cecidomyia destructor*, or Hessian Fly. By Margaretta H. Morris. Proceedings of the Academy of Natural Sciences of Philadelphia, i, pp. 66–68 1841; iii, p. 238, 1847; iv, p. 194, 1849. Transactions of the American Phil. Society of Philadelphia, ser. 2, viii, pp. 49–51, 1843.

COATES. Remarks on the Present State of the Evidence in regard to the Hessian Fly. By Benjamin H. Coates, M. D., 1841.

———. Note on the natural alliances of the genus Cecidomyia, intended to facilitate identification. By B. H. Coates. Proceedings Acad. Nat. Sci. Phila., i, pp. 191–192, 1842.

COATES. On some larvæ in wheat stalks. By B. H. Coates. Proceedings Acad. Nat. Sci. Phila., i, pp. 45, 54–57, 1842.

BERGEN. Remarks on the Hessian Fly. By Garret Bergen. Cultivator, viii, Albany, Aug., 1841.

HERRICK. A brief preliminary account of the Hessian Fly and its parasites. By Edward C. Herrick. American Journal of Science and Arts, xli, New Haven, pp. 153–158, Oct., 1841.

———. Observations on the Hessian Fly. By E. C. Herrick. Report of the Commissioner of Patents for 1844, Washington, 1845, Appendix, pp. 161–167. See also letters to Dr. T. W. Harris in Entomological Correspondence of T. W. Harris, and the Connecticut Farmers' Gazette, No. 40.

HARRIS. A Report on the Insects of Massachusetts Injurious to Vegetation. By Thaddeus W. Harris. Cambridge, 1841, pp. 421–433. Reprint, 1842. Second edition, Boston, 1852. Third edition, with illustrations, 1862.

———. Article by T. W. Harris in New England Farmer, xx, pp. 409–410, 1842.

———. Entomological Correspondence of Thaddeus William Harris, M. D. Edited by Samuel H. Scudder. Occasional Papers of the Boston Society of Natural History, i, Boston, 1869, 8°, pp. 181–207.

CURTIS. Observations, &c., including a saw fly, the Hessian Fly, the wheat midge, and the barley midge. By John Curtis. Journal of the Royal Agricultural Society of England, vi, pp. 131–156, pl. 1, 1845. Separately printed, London, 1845, 8°, pp. 28, pl. 1.

———. Farm Insects. By John Curtis. London, 1860, p. 258.

WESTWOOD. Article on the Hessian Fly. By John O. Westwood. Gardeners' Chronicle, London, p. 604, 1847.

YUKES. Notice by J. D. Yukes. Patent Office Report, Washington, 1850.

FITCH. The Hessian Fly; its history, character, transformations, and habits. By Asa Fitch, M. D. [originally published in the American Journal of Agriculture and Science, iv, v, 1845, and now revised by the author]. Transactions of the New York State Agricultural Society, vi, 1846; Albany, 1847, 8°, pp. 316–373, with a plate. Printed separately, Albany, 1846, 8°, pp. 63, with a plate; and also Albany, 1847, 8°, pp. 60, with a plate.

———. Seventh report on the noxious and other insects of the State of New York. By Asa Fitch, M. D. Pp. 133–144, with a plate, 1862.

MOTSCHULSKY. Article by Victor Motschulsky in Journal du Ministère de l'Intérieur, 1852.

HIND. Essay on the Insects and Diseases Injurious to the Wheat Crops. By H. Y. Hind, Toronto, 1857, pp. 38–74.

SICHEL. Article by Jules Sichel in Annales de la Société Entomologique de France, iv, Bulletin, p. 8, 1856.

HILL, Rev. GEORGE S. J. Essay on the Hessian Fly, Wheat Midge, and other Insects. Injurious to the Wheat Crops. Toronto, Canada, 1858, 8°, pp. 52, illustrated.

———. Transactions of the Board of Agriculture of Upper Canada, Vol. iii, pp. 25–72, 1858–'59.

LOEW. Ueber die den Roggen in den Prov. Schlesien und Posen verwüstende Fliegenmade. By H. Loew, in Zeitschrift Entomol. schles. Verein für Insektenkunde, 1858, xii.

———. Die neue Kornmade und die Mittel, welche gegen sie anzuwenden sind. Züllichau. Sporleder, 1859, 8°, p. 29.

KLIPPART, J. H. The Wheat Plant. * * * Cincinnati, 1860. 12. Pages 608–614 devoted to Hessian Fly, with illustration.

WAGNER. Untersuchungen über die neue Getreidegallmücke. Von Dr. Balthasar Wagner. Fulda und Hersfeld, 1861, 4°, pp. 41, with a plate.

OSTEN SACKEN. Article by R. von Osten Sacken in Stettiner entomologische Zeitung, 1862, p. 80.

HABERLANDT. Article by Haberlandt. Verhandlungen zool.-botan. Gesellschaft, Wien, 1864, p. 401.

KÜNSTLER. Article by Künstler. Verhandlungen zool.-botan. Gesellschaft, Wien, 1864, pp. 407, 779; 1871, p. 15.

WALSH. Brief notices by B. D. Walsh, editor of the Practical Entomologist, 1867, pp. 10, 37.

STIERLIN. Article by Stierlin in Mittheilungen der Schweiz. entomol. Gesellschaft, 1868, ii, p. 157.

COHN. Untersuchungen über Insectenschaden auf den schlesischen Getreidefeldern im Sommer 1869, 1869, p. 12.

KALTENBACH. Die Pflanzenfeinde aus der Klasse der Insekten. Stuttgart, 1874, pp. 734, 738, 741.

RUDOW. Die Pflanzengallen Norddeutschlands und ihre Erzeuge. 1875, p. 84.

BERGENSTAMM and LOEW. Synopsis Cecidomyidarum. Von J. E. von Bergenstamm und Paul Loew. Aus den Verhandlungen der K. K. zoologisch-botanischen Gesellschaft in Wien, 1876, 8°, p. 104.

PACKARD. Guide to the Study of Insects. By A. S. Packard, jr., M. D. 8°, first edition, 1868-'69, pp. 374-375, Salem, Mass. Second edition, 1870. Third edition, 1872. Fourth edition, 1874. Fifth edition, 1876. Sixth edition, New York, 1878. Seventh edition, New York, 1880.

———. Our Common Insects. Salem and Boston, 1873, 12°, pp. 79, 196.

———. Half Hours with Insects. Boston, 1877, 12°, pp. 212-215.

———. Report on the Rocky Mountain Locust and other Insects now injuring or likely to Injure Field and Garden Crops in the Western States and Territories. By A. S. Packard, jr., M. D. (Published in Report of the United States Geological Survey of the Territories, F. V. Hayden in charge, 1875.) Washington, 1877, pp. 695-697. Fifty extra copies with a separate title page: The Injurious Insects of the West. Salem, *S. E. Cassino*, 1877, 8°, pp. 589-815, this being the original pagination, with a map showing the distribution of the Hessian Fly.

———. The Hessian Fly, its ravages, habits, enemies, and means of preventing its increase. By A. S. Packard, jr. Bulletin No. 4, United States Entomological Commission, Washington, May 20, 1880, 8°, pp. 43.

COOK. The Hessian Fly. A lecture by Prof. A. J. Cook. Michigan, 1878, 8°, p. 14.

RILEY. Report of the Entomologist, Charles V. Riley, M. A., Ph. D., August 22, 1879. (Author's edition, from the Annual Report of the Department of Agriculture for the year 1878.) Washington, 1879.

———. Hessian Fly and Wheat Rust. New York Weekly Tribune, Dec. 19, 1877.

———. Fighting the Hessian Fly. New York Weekly Tribune, Sept. 12, 1877.

———. The Hessian Fly. Saint Louis Illustrated Journal of Agriculture, June 14, 1877.

HAGEN. The probable Parthenogenesis of Cecidomyia destructor. By Dr. H. A. Hagen, North American Entomologist, vol. 1, No. 9, p. 65, 66, March, 1880. (Noticed in American Entomologist, iii, p. 127, May, 1880.)

———. The Hessian Fly not imported from Europe. By Dr. H. A. Hagen, Canadian Entomologist, 197-207, Oct., 1880.

PART III.

DESCRIPTIONS OF LARVÆ OF INJURIOUS FOREST INSECTS.

THE EMBRYOLOGICAL DEVELOPMENT OF THE LOCUST. (*Caloptenus.*)

THE SYSTEMATIC POSITION OF THE ORTHOPTERA IN RELATION TO OTHER ORDERS OF INSECTS.

NOTE ON THE GEOGRAPHICAL DISTRIBUTION OF THE LOCUST AND OTHER INSECTS (MAP IV).

CHAPTER IX.

DESCRIPTIONS OF THE LARVÆ OF INJURIOUS FOREST INSECTS.

(Plates VI–XV.)

The following descriptions were drawn up after the publication of our Bulletin No. 7, on Forest Insects; and it is believed that these notes, and especially the accompanying illustrations, will have considerable practical interest. The drawings have all been made by Dr. C. F. Gissler, under the author's direction, and acknowledgment should be made of the care and pains taken by Dr. Gissler in representing these difficult subjects for illustration. Full references to the figures are given in the explanations of the plates.

Family BUPRESTIDÆ.

THE FLAT-HEADED APPLE BORER.

Chrysobothris femorata (Fabricius).

The following description has been drawn up from fresh alcoholic specimens, from the localities mentioned in Bulletin 7, p. 16.

Prothorax very broad, being broader and flatter and the abdominal segments smaller in proportion than any other borer of this family known to us. Head retracted within the prothorax. The disk finely shagreened with raised dots. A narrow inverted V-shaped smooth impressed line in the middle of the disk, the apex becoming prolonged towards but finally becoming obsolete at the front edge of the disk; the arms of the V behind not reaching very near the posterior edge of the disk. Beneath, is a similar roughened disk, but more regularly rounded-oval than above, and with a single straight median swollen impressed line, which is a little over one-half as long as the disk, but which reaches a little nearer the front than the hind edge.

2d thoracic (mesothoracic) segment very short, considerably shorter and wider than the 3d, with an oval slightly rough area on each side of the median line, the similar area on the 3d thoracic segment being larger and united over the median line.

The ten abdominal segments of uniform width, being a little shorter than broad, except the small 10th segment, which is about two-thirds

as wide as the 9th. A pair of irregular rather long patches on each abdominal segment above, and a pair of curvilinear impressed lines beneath.

One pair of mesothoracic and eight pairs of abdominal spiracles.

Head a little narrower than the thoracic disk. Clypeus corneous, square in front, very short and broad. Labrum square, a little longer than wide, front edge moderately rounded, densely hirsute. Antennæ 3-jointed; 1st joint short, membranous, 2d considerably narrower, 3d minute, rounded at tip, considerably slenderer than 2d. Mandibles entirely black. Maxillary lobe[120] short, projecting slightly beyond the edge of labium. Maxillary palpus 2-jointed, 2d joint not so long as the 1st is wide, one-third as thick, and extending a little beyond the maxillary lobe. Labium entire, the front edge not being excavated.

Length, 22^{mm}; breadth of prothoracic segment, 7^{mm}; length, 4^{mm}; width of 6th abdominal segment, 3^{mm}.

Pupa. Body flattened, and of the general shape of the imago. The antennæ seen from above extend to a little behind the outer hinder angle of the prothorax. The elytra reach to the middle of the 4th abdominal segment. The wings extend as far as the hinder edge of the same segment. The 3d pair of tarsi reach to near the middle of the 6th abdominal segment. Six pairs of abdominal spiracles. Length, 15^{mm}; breadth, 7^{mm}.

In transforming, the eyes, the front of the head, the prothorax, the femora and tibia and portions of the sternum and under side of the abdominal segments, turn dark first.

CHALCOPHORA, probably C. VIRGINICA. Pl. VI, fig. 1.

Compared with Dicerca the head is much larger and better developed, while the prothorax is of the same size, and the abdomen is fully as thick, but rather longer. Prothorax and the V-shaped mark one-half narrower than in *Chrysobothris femorata*, and with no markings around the apex, as in Dicerca. The prothoracic disk has very large, coarse, transverse, raised linear chitinous points, which are more or less confluent, forming irregular transverse wavy ridges. The disk on the under side has similar markings, and a single narrow deeply impressed median line, which extends from the front to the hinder edge.

No roughened area on the succeeding segments, but on the mesothoracic are two remote converging curved lines, and on the metathoracic segment are similar lines, which extend nearer the front edge; the curved lines inclose a subtrapezoidal space.

Antennæ large and well developed, compared with those of Dicerca and Chrysobothris; 3-jointed; the basal joint membranous, 3d joint nearly as long as the 2d, and blunt at tip. Labrum rounded on the edge, fuller than in Dicerca. Maxilla large and well developed; maxil-

[120] What is here called maxillary lobe corresponds to the *mala interior* of Schiödte, De Metamorphosi Eleutheratorum Observationes. Naturhistorisk Tidsskrift, 3d ser., vol. 1.

lary lobe smaller in proportion to the base of the maxilla than in Dicerca or Chrysobothris. Palpus 2-jointed; basal joint much larger than the maxillary lobe (in Dicerca and Chrysobothris it is much smaller); 2d joint one-fourth as large as 1st, being proportionally much smaller than in the above-mentioned genera. Labium much as in the said genera, being rounded in front.

Total length of body, 41^{mm}; length of prothorax, 5^{mm}; breadth, 8^{mm}; length of the three thoracic segments together, 8^{mm}; breadth of 4th abdominal segment, 4^{mm}.

The hairs on the body are much coarser than in the other genera mentioned.

This larva may be distinguished by the large head, the well-developed antennæ, the large maxillæ, with the lower joint of maxillary palpus small; by the very coarse and linear markings on the prothoracic disk above and beneath; by the absence of roughened areas or callosities on the meso and metathoracic segments, and by the long, thick abdomen.

The mesothoracic segment is shorter and the metathoracic is as long as in Dicerca.

Compared with Loew's figure of the larva of Chalcophora (Ent. Zeitung, Stettin, 2ter Jahrgang, 1841, Tab. 1, figs. 1–8) our species differs mainly in the larger chitinous prothoracic disk, though the V-shaped mark is the same. In the shape of the body, in the form of the mesothoracic and metathoracic segments, and the end of the abdomen, our larva appears to be a Chalcophora. The 1st abdominal ring is longer and narrower than in Loew's figure. The labrum is peculiar in this genus, on account of the lateral lobes; in this respect it resembles the figure of Loew; while the antennæ, maxillæ, and labium are nearly as he figures them. Under these circumstances we think there is no reasonable doubt but that this larva is a Chalcophora, and probably, from its large size, *C. virginica*, which, according to Harris, bores in the pine.

The two specimens described were taken from under the bark of the pitch pine, May 26, Providence, R. I.

MELANOPHILA sp. Pl. VI, fig. 4; XII, fig. 1.

Head of moderate size. Antennæ very short, 3-jointed; 2d joint much shorter than long, 3d very short and blunt, much more so than the unknown (spruce) genus, or in Chrysobothris or Dicerca. Labrum much as in the other genera mentioned, rather narrow, and moderately full on the front edge. Maxillary lobe well developed, with a spine pointing inwards; maxillary palpi with the 2d joint as long as the 1st. Labium slightly indented in the middle, but so slightly so that it cannot be represented in a figure. Mandibles tridentate.

Prothorax unusually short, about half as long as broad, the sides well rounded; the roughened chitinous disk is very small, not much over one-third as wide as the entire segment; it is round, slightly longer than broad, inclosing a narrow inverted V, which extends the whole

length of the disk. On the under side the disk is subtrapezoidal, widening at base, the sides hollowed out, and narrower than long. The meso- and metathoracic segments unusually long, and of the same size, being about two-thirds as wide as the prothorax.

1st abdominal a little shorter than the 2d abdominal segment; segments 2 and 8 of the same size, and very full and rounded on the sides. The 9th segment somewhat narrower than the 8th, and the 10th is one-third to one-half as wide as the 9th. Length 12–19^{mm}; in one 12^{mm} long the prothorax is 1^{mm} long and 2.5^{mm} broad; the 8th abdominal segment about 1.5^{mm} broad.

This is evidently a species of Melanophila, and differs from the other genera mentioned in the short and wide prothoracic segment, in the very small disk inclosing a narrow V, and being trapezoidal beneath, while the abdominal segments are very convex, and broad in proportion to the prothorax. It may also be identified by the very slightly bilobed labium and well-developed maxillæ.

This is No. 2 "unknown Buprestid larva," on the spruce, p. 228 of Bulletin 7, and No. 4, p. 241, on the hemlock.

FLAT-HEADED SPRUCE BORER. (*Melanophila?*)

In the form and size of the head, prothorax, and body, including the 10th segment, closely like Dicerca, but the sculpturing is decidedly different. The description of the proportions of the prothorax and succeeding segments of the body in Dicerca will apply to this species. The prothoracic disk is, however, very different; it is transversely rounded-oval, very regular in shape, and smaller than the disk of Dicerca; it is considerably wider than long, and the sides are well rounded; the surface of the disk is slightly convex and covered with short linear chitinous raised markings, which do not, however, form curvilinear lines, except in a slight degree on the hinder edge, especially in the inverted V. The V-shaped mark is much as in Chrysobothris. The raised markings on the disk differ decidedly from those of Chrysobothris in not being round dots, but transversely linear in form. The apex of the V is not inclosed in a square area, as in Dicerca, and the V is much narrower. The disk on the under side of the prothoracic segment is much as on the upper, the V being represented by a simple median line. A pair of mesothoracic stigmata, and eight abdominal pairs. Head of the same size as in Dicerca. Labrum much rounded on the front edge, and much more contracted at the insertion in the fleshy clypeus than in Chrysobothris. Antennæ with the 2d joint a little longer than in Dicerca, the 3d joint about one-third as long as the 2d joint, tomentose and rounded at tip. Labium longer, fuller, more rounded on the front edge, and a little narrower than in Dicerca, the edge not being notched. It is more contracted at base than in Dicerca, and the rudimentary palpi are more distinct than in Chrysobothris or Dicerca. Maxillæ a little slenderer than in Dicerca and Chrysobothris, 3-jointed; maxillary lobe much

narrower, one-third less so than in Dicerca, but not reaching beyond the distal end of the 2d palpal joint. The two palpal joints are a little longer and slenderer than in Dicerca; 1st joint much narrower than in Dicerca, the 2d joint conical at tip, and as long as the 1st is thick.

Entire length, 20 ^{mm}; length of prothorax, 3^{mm}; breadth, 5^{mm}; breadth of 8th abdominal segment, 2.5^{mm}.

This is not an Ancylocheira nor Anthaxia, according to Perris' figures, but is related to Melanophila. Unlike the larvæ of this genus, however, it has no "unguiform spine," but three equal radiating spines on the tip of the lobe, while the ligula is entire. It cannot be a Buprestis (*B. maculiventris*) as it differs from Buprestis (Ancylocheira) as described by Perris, in the entire labium and the much longer labrum as well as the much shorter lobe of the maxilla and in the marking of the prothorax.

It occurred on the spruce at the Glen, White Mts., N. H., and under the bark of spruce, at Brunswick, Me., August 27.

THE FLAT-HEADED PEACH AND CHERRY BORER.

Dicerca divaricata Say. Pl. VI, fig. 2.

In addition to the description given on p. 108 of Bulletin 7, the following characters may be given. The mouth-parts are as described in *Chrysobothris femorata*, and a drawing could not well show the generic or specific differences between *Chrysobothris femorata* and *D. divaricata* as regards these parts. They are as described in *C. femorata;* the labium is the same, but with the front edge perhaps a little less full and rounded. The maxillæ are perhaps a little fuller. Antennæ the same, the 3d joint minute and rounded. On the whole, the antennæ and maxillæ are a little stouter, and slightly more developed than in *C. femorata.* The labrum is, however, less full and rounded on the front edge. On the mesothoracic segment is a transverse narrow chitinous area, while that on the metathoracic segment is of a double lunoid shape. The 1st abdominal segment has a short, narrow dorsal area, shorter than the one on the preceding segment. The lateral linear crescent-shaped impressed lines are well marked.

This larva differs from that of *Chrysobothris femorata* in being considerably larger, the abdominal segments being thicker in proportion to the prothorax, and also in the style of sculpturing on the prothorax. The apex of the V is surrounded by a square, deeper-colored area; the disk on the under side is divided by a double line, which widens suddenly in front into halves.

BUPRESTID UNDER BARK OF HEMLOCK. Pl. VI, Fig. 5.

The accompanying figure represents a Buprestid larva, mentioned in Bulletin 7, p. 241 (No. 4).

It is 20^{mm} in length, and Dr. Gissler's figures so well represent the larva, that a longer description will not at this time be needed.

Family CERAMBYCIDÆ.

LONGICORN LARVA UNDER BARK OF THE HEMLOCK.

Plate XII, Fig. 5, represents the Longicorn larva mentioned on p 241 of Bulletin 7 (No. 2), as found in abundance under the bark of the hemlock at the Glen, N. H., July 22.

It is 19^{mm} in length; width of the prothoracic segment, 4.5^{mm}.

LONGICORN LARVA UNDER BARK OF HEMLOCK.

Plate XII, Fig. 6, represents a Longicorn larva found under the bark of the hemlock, and mentioned on p. 241, Bulletin 7 (No. 3), as having occurred at Bath, Me., July 30.

The body is remarkably short and thick; as wide near the end as across the prothoracic segment. It is 20^{mm} in length. Mandibles rounded; antennæ long and slender, 4-jointed; maxillæ with the lobe long, extending as far as the end of the 4-jointed palpi. Labium narrow. palpi, large, 3-jointed. Labrum small and narrow.

SAPERDA ON THE WILLOW.

Plate XI, Fig. 4; XII, fig. 4, represents a larva found by Dr. Watson, in the willow.

It is 16^{mm} in length; prothoracic segment 3^{mm} wide. A pair of prothoracic spiracles, and the usual eight pairs of abdominal ones. Antennæ 4-jointed; labrum as long as broad; maxillæ with the lobe very large, extending far beyond the palpi, which are small and 3-jointed. Labium broad and short; palpi short, 3-jointed. Mandibles rounded at tip.

THE LESSER PINE BORER.

Asemum moestum Haldeman. Pl. IX, Fig. 1.

Prothorax inclined downwards towards the head; quite long and not very wide, being no wider than the mesothoracic and metathoracic segments, the squarish area being very long, naked on the basal third, the front margin pale brown, chitinous. Mesothoracic and metathoracic segments as wide as the prothoracic; the metathoracic slightly longer and fully as broad as the mesothoracic segment. Abdominal segments rather broad, the 2d the shortest, and the 7th the longest; the 8th two-thirds as long as the 7th and considerably narrower; the 9th one-quarter as long as the 8th and three-fourths as wide; the 10th only seen from beneath, and about two-thirds as wide as the 9th, and bilobed at the end. On the two hinder thoracic and the 1st abdominal segment are transverse regular oblong areas bounded by impressed lines; on segments 2–4 the callosities are narrower, and the anterior side is pointed; on the 6th and 7th they are a little longer than broad and contracted posteriorly. Beneath are similar callosities, but the anterior edge is feebly in-

dicated, the sides being most distinct. Thoracic feet minute, 3-jointed, small and rather short; 3d joint one-half as thick as the 2d.

Head: clypeus very small, membranous; labrum small, narrow, though longer than wide, and well rounded in front; mandibles solid, thick, rounded at tip; antennæ 4-jointed, rather slender; 2d joint about one-half as long as the 1st and about one-quarter shorter than the 3d; the 4th minute, slender, about two-thirds as long as the 3d is wide. Maxillæ with the lobe rather broad, not very hairy, extending as far as the end of the maxillary and labial palpi; maxillary palpus 4-jointed; 1st joint much shorter than long, flattened, spherical; 2d subspherical; 3d one-half as long as the 2nd; 4th longer than 3d, but only about one-half as thick. Mentum narrow, about one-third as long as wide; ligula long and narrow; labial palpi 3-jointed; 1st joint a little longer than thick; 2d very short, spheroidal, a little less than one-third as long as 1st; 3d conical, considerably longer than the 2d and one-half as thick.

Length, 12^{mm}; length of prothoracic segment, 2^{mm}; breadth, 3^{mm}; breadth of 8th abdominal segment, 2.5^{mm}.

THE OAK BORER.

Elaphidion parallelum Newman. Pl. VII, Fig. 1.

The body very closely resembles *X. colonus*, but is larger and broader, especially on segments 7–9, but in general appearance is closely similar. Prothoracic segment scarcely wider than the mesothoracic, but not so much swollen as in Xylotrechus. The disk is regularly transversely oblong, the sides not convex but straight, the edges in front and on the sides brown. The disk is one-half as long as broad; posterior half free from hairs, not so distinctly marked as in *X. colonus*, but the longitudinal irregular pale streaks are present. The mesothoracic and metathoracic segments are as wide as the prothoracic, but the mesothoracic is a little shorter than the metathoracic. The mesothoracic segment is divided into two lateral portions by a scutel-like, very short and broad callosity which is narrow, lanceolate-oval. The metathoracic segment has a similar callosity, but a transverse fleshy ridge is present, not found on the mesothoracic segment. Beneath, a callous brown spot incised in the middle, longer and narrower than those on the six succeeding segments. That on the prothoracic is much shorter and narrower than on the mesothoracic, the latter not divided mesially, where those on the metathoracic and three succeeding segments are partly divided by the median line of the body, forming two irregular oval patches touching the median line of the body, and with the outer, hinder edge produced a little posteriorly. On the 1st abdominal segment is a transverse, short but very wide crescent-shaped callosity with swollen margins; on the succeeding segments these become longer and narrower, until on the 4th segment they become one-half as long as broad; on the hinder segments (5–7) they become still longer and transversely oblong-

oval, with irregular broad thickened patches. Beneath, on the segments behind the 4th the callosities disappear, but there are raised smooth oval areas. A pair of thoracic feet on each of the three segments; they are 3-jointed, basal joint membranous; 2d joint about three-fourths as long as wide; 3d joint about two-thirds as wide as the 2d, and slightly longer. The 9th abdominal segment but little narrower than the 8th; the 10th about one-third as wide as the 9th. A pair of mesothoracic spiracles, and eight abdominal pairs.

Head not quite so large in proportion as in *X. colonus*. Labrum small, not quite so broad as in *X. colonus*, convex and well rounded in front, and very hairy. Mandibles black.

Antennæ 4-jointed, 1st joint apparently divided into two subsegments; 3d a little longer and narrower than the 2d; the 4th minute, obtuse, one-half as long as the 3d is wide. Maxillæ with the lobe rather small, reaching to near the end of the 3d joint of the palpus. Maxillary palpi 4-jointed, 2d joint slightly shorter and narrower than the 1st; 4th half as thick as the 3d, and pointed at the tip. Labium with the mentum nearly square, narrower than the submentum. The ligula, which is very small in *X. colonus*, is here entirely wanting. Labial palpi 3-jointed; 2d joint not so long as wide; 3d very long and slender, a little longer than the 2d and about one-half as thick; they reach as far as the end of the 3d maxillary palpal joint.

Length, 17^{mm}; breadth of prothoracic segment, 5^{mm}; length, 2^{mm}; breadth of 8th abdominal segment, 3.5^{mm}.

This larva may be recognized by the stout, thick thoracic feet, by the rather small prothoracic segment compared with the two hinder ones, by the absence of the ligula, by the large well-developed palpi and antennæ, and by the shape of the callosities.

THE COMMON OAK CLYTUS.

Xylotrechus colonus (Fabr.). Pl. XII, Figs. 2, 2*a*.

Body of the usual shape, near that of Phymatodes. Prothorax less than one-half as long as wide; disk exactly one-half as long as wide; the disk is smooth on the posterior half, irregular on the front edge, with a broad irregular median lobe in front; the front edge of this smooth space is often tinged with dark. In front of this smooth area is a clear, pale, hairy space, and still beyond (anteriorly) are two irregularly oval spaces which are hairy and irregularly spotted, and often tinted dark. The under side of the prothoracic segment is quite hairy, with minute oval patches among the hairs, and with two conspicuous small dark diverging patches on the middle of the segment, but situated rather far apart. Mesothoracic segment a little narrower than the prothoracic and shorter than the metathoracic segment, the latter a little shorter and but very slightly wider than the mesothoracic segment.

Body contracted on the 6th abdominal segment, which is considerably narrower than the succeeding part of the abdomen, the 7th abdominal segment being wider than the 6th, and of the same width as the 8th; the 9th much shorter and two-thirds as wide as the 8th. The 10th segment small, one-half as wide but nearly as long as the 9th. Abdominal segments 2–7 with transversely oval raised smooth callosities, those on the 6th and 7th being round instead of oval; beneath are similar callosities.

Head a little over one-half as wide as the prothoracic segment; antennæ 3-jointed; 2d joint one-half to two-thirds as long as the 1st and one-half as thick; 3d minute, about one-third as long as the 2d joint is thick. Maxilla with the lobe as wide as the basal joint of the palpus, and reaching to the end of the 2d palpal joint; the maxillary palpi 4-jointed, the 2d joint one-half as wide as the 1st; the 3d just two-thirds as wide as the 2d; the 4th as long but one-half as thick as the 3d.

Labium with the ligula small and rounded, not more than one-third wider than the basal joint of the labial palpus, the latter 2-jointed, the 2d joint nearly as long and about two-thirds as thick as the 1st. Mentum deeply cleft, one-half as long as the submentum.

Labrum small, rounded, not so long as round, surface convex, with dense hairs. Mandibles obtuse, rounded, not toothed.

Length of body, 17^{mm}; width of prothoracic segment, 4.5^{mm}; length, 2^{mm}; width of 7th abdominal segment, 3^{mm}. Thoracic spiracles in the middle of the mesothoracic segment, with the usual eight pairs of abdominal ones.

Pupa as described in Bulletin 7. The end of the body terminates in a pair of incurved hooks on each side, the inner pair a little smaller than the outer. Six large recurved spines on the penultimate abdominal segment, the other abdominal segment with about two irregular rows of minute stout spines adapted for progression.

CLYTUS? LARVA ON THE BLACK BIRCH.

Plate XII, Fig. 3, represents the mouth-parts of a Clytus nearly allied to if not identical with *X. colonus.*

THE RIBBED RHAGIUM.

Rhagium lineatum Olivier. Pl. XI, Figs. 1, 2.

The following description gives the characters more fully than in Bulletin 7, p. 162:

Body long and narrow, head remarkably large, as wide and as large as the prothoracic segment.

Head behind with a triangular incision; the apex of the incision is met by a curved line passing back from the outside of the antennæ, dividing the epicranium into two areas. Clypeus more solid than usual. Labrum about twice as wide as long, and moderately rounded in front.

Antennæ minute, very short, 2-jointed, the joints much shorter than broad (when retracted), and the 2d joint blunt at tip. Mandibles large, with three teeth on the cutting edge. Maxillæ composed of two broad segments, and a third narrower one bearing the maxillary lobe and palpus; the lobe long and narrow, curved inward, reaching to the middle of the 3d palpal joint; palpus 3-jointed, the basal joint somewhat swollen at the end; 2d as long as the 1st, tapering toward the distal end; 3d small, conical, as long as the 2d is thick. Mentum wider than long, square; ligula square, but slightly convex on front edge; labial palpi 3-jointed, 2d joint a little slenderer than 1st, but of the same length; 3d joint slender and as long as the 2d is thick.

Prothoracic segment not so much wider than the rest of the body as in the Longicorn larvæ in general; sides straight, retreating posteriorly; surface flat and chitinous; meso- and metathoracic segments as wide as the prothoracic, but a little more than one-half as long as the 1st abdominal segment. Thoracic feet long and slender, 4-jointed, the 4th joint minute, corneous, 2d and 3d joints of the same length, the 3d two-thirds as thick as the 2d.

Abdominal segments increasing very slightly in length to the 8th, which is slightly longer than the preceding ones, but a little narrower than the 7th; the 9th shorter and nearly one-quarter narrower than the 8th; the 10th scarcely visible from above, one-quarter to one-fifth as wide as the 9th, and deeply cleft posteriorly. Callosities very large, soft, not well defined, being elongate, transversely-oval areas, bounded laterally by curvilinear impressed lines. Beneath, the callosities are a little more distinctly marked, with a transverse deeply-impressed straight, median line into which short curved lines pass, the whole area being oval-cylindrical, compressed in the middle. The hairs on the body rather long.

Length of the body, 26–30^{mm}; in one 30^{mm} in length the head is 3–4^{mm} long and 6^{mm} broad; prothorax 2.3^{mm} long and 6^{mm} broad; breadth of 8th abdominal segment, 5^{mm}.

This larva is very common under the bark of pines which have been cut down for a year or more, so that the larva evidently gets its growth in a year. It may be easily recognized by its large size, the broad, flattened head and body, the latter not narrowing behind; the prothorax is small in proportion to the head, while the antennæ are minute, 2-jointed. The form of the body, and especially of the hard, corneous head, admirably adapts it for its work of loosening the bark, and thus forwarding the decay of stumps and fallen trees.

THE LESSER PRIONUS.

Orthosoma brunneum (DeGeer). Pl. X, Fig. 1.

In addition to the description on p. 161 of Bulletin 7, the following characters may be noted:

Head about one-half as wide as the prothorax. Front edge of epicra-

nium rough, black, and with a spine on each side below, projecting over the clypeus ("epistoma" of Perris); upper edge overhanging and irregularly denticulated. Clypeus subchitinous. Labrum much broader than long, well rounded in front, with numerous stiff bristles. Antennæ 3-jointed; basal joint partly covered by a projection from the epicranium; 2d joint one-half as long and about three-fourths as thick as the 1st; 3d joint nearly three times as long as the 2d, somewhat barrel-shaped, being contracted at base and obtusely conical at the distal end. Maxillæ with the lobe well developed, the lobe not being very broad, abundantly bristled, and extending as far as the end of the 3d palpal joint. Maxillary palpus 4-jointed; 3d joint but slightly longer than the 2d, the 4th as long as the 3d, but one-half as thick, conical, pointed at the end, and extending well beyond the closed mandibles.

Labium: mentum short and very broad; ligula nearly as long as broad, front edge well rounded. Palpi 2-jointed; basal joint thick and short, globose, 2d joint conical, contracted in the middle as if subsegmented. Mandibles acute, slightly bidentate.

Feet moderately stout, 3-jointed, the two basal joints nearly alike, the 3d conical, and bearing a single claw.

Length of the specimen, 75^{mm}; width of prothorax, 11.5^{mm}; of prothoracic disc, 10^{mm}; length of prothorax, 8^{mm}; length from base of head to tip of labrum, 4^{mm}; width of head, 6^{mm}; length of antenna, 0.8^{mm}; of leg, 0.6^{mm}; width of mesothoracic segment, 12.5^{mm}; of 1st abdominal segment, 11.5^{mm}; of 4th abdominal segment, 10^{mm}; length of 8th abdominal segment, 4^{mm}; of 9th, 8^{mm}.

UNKNOWN LONGICORN BORER FROM AN OAK LOG. Pl. XI, Fig. 3.

Body of large size, gradually tapering to the penultimate segment, with three pairs of thoracic legs of moderate size.

Head small and much rounded. Labrum small and unusually narrow, well rounded on the front edge. Antennæ conspicuous, unusually long; 2d joint very long and slender, longer than the basal one is thick; 3d joint minute and acute at tip. Labium very small, squarish; submentum and mentum both rectangular, broader than long; the ligula narrow, much rounded in front; labial palpi 3-jointed; 3d joint obtuse, as long as the 2d. Maxillary lobe very broad and rather short, not reaching beyond the end of the 2d palpal joint. Maxillary palpi 3-jointed; 1st joint very short and broad; 2d one-half as thick as the 1st, the 3d slender and a little longer than the 2d. Mandibles much rounded and entire at tip.

The callosities on the segments, as figured in the cut, are prominent, more or less rounded tubercles with the surface divided irregularly by impressed lines.

Length, 35^{mm}; width of prothoracic segment, 8^{mm}; length, 3^{mm}; length of a leg with terminal claw, 0.4^{mm}; length from base of labrum to posterior edge of metathoracic segment, 5^{mm}; length of 1st and 2d abdomi-

nal segment, each, 2^{mm}; length from base of 3d abdominal segment to end of body, 28^{mm}; width of each of segments 2–6, 6^{mm}; the 7th and 8th segments are slightly wider.

Found in an oak log at Providence, R. I., May 20, 1881.

UNKNOWN LONGICORN LARVA IN THE SYCAMORE. Pl. X, Fig. 2.

Body rather flattened, broader behind than usual, the penultimate segment being much wider than usual. Head large and prominent, square and flat, somewhat as in Monohammus, being one-half as wide as the prothoracic segment. Mandibles acute, unequally 2-toothed, the terminal tooth much the larger. Antennæ very short and thick, 2-jointed; 2nd joint extremely small, with two outer spines on the 1st joint. Near the antennæ on the head are five long bristles. Labrum much rounded in front, as long as broad. Labium broad, with 2-jointed palpi; 2d joint acute, as long as the 1st is thick. Maxillary lobe narrow, reaching to the end of 2d joint; 3d joint about as long as 2d, rather blunt. No thoracic feet. Prothoracic segment about one-third as long as broad, with a roughened spur on the posterior half; the front edge quite hirsute. The markings or callosities on the back are difficult to describe, but are as figured by Dr. Gissler.

Length, 15^{mm}; width of prothoracic segment, 4^{mm}; length, 1.6^{mm}; average width of the body, 3.8^{mm}; length from tips of mandibles to base of head, 1.6^{mm}.

Larva found under bark of sycamore tree in Brooklyn, N. Y. Received from Dr. C. F. Gissler.

Pupa.—Plate XIV, Fig. 8, represents a Longicorn chrysalis, taken from under the bark of the same sycamore tree as the larva above described, and which may possibly belong to the same species.

NOTE.—A number of other larvæ, including those of certain Scolytidæ, are figured on Plates XII–XV. See explanations of those plates.

CHAPTER X.

THE EMBRYOLOGICAL DEVELOPMENT OF THE LOCUST.

Plates XVI–XXI.

In order that the reader may understand the following statements regarding the embryology of the locust, which are more or less fragmentary in their nature, we preface our account with a brief description of the developmental history of winged insects in general so far as it is now known.

Formation of the blastoderm.—The changes which take place in the egg immediately after fertilization are not known beyond the fact that segmentation of the yolk is partial, being confined to the periphery. The only observations yet published are those of Bobretsky[121] on a butterfly (*Pieris cratægi*) and a moth (*Porthesia chrysorrhœa*). After fertilization there first appear scattered through the yolk a few (the smallest number 4) cell-like, minute, amœboid masses of protoplasm, each with a distinct nucleus. A few (one at least) of these bodies gradually pass out of the center of the yolk to the surface of the egg (Fig 10 A, *n*), these becoming larger and rounder, and from one or two of these nuclei (Fig. 10 B, *b c*) the so-called blastoderm originates (Fig. 10 C, *bl*). Those nuclei remaining in the yolk increase in number and afterwards become the nuclei of rounded masses of yolk-granules, forming the so-called yolk-spheres which Bobretsky regards as true cells.

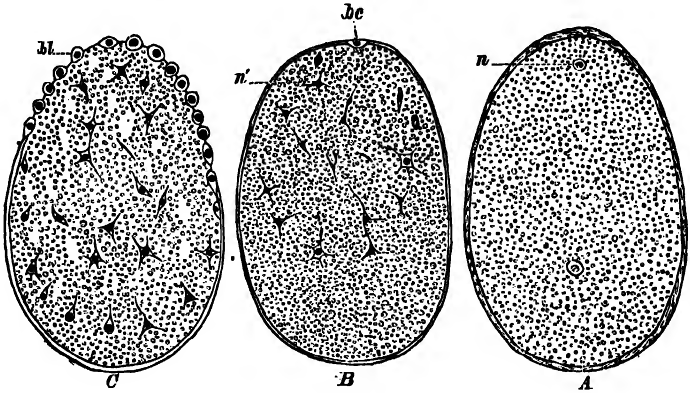


FIG. 10.

To the few blastoderm cells situated on the upper end of the egg are added others which continue to pass from the yolk to the periphery,

[121] Zeitschrift für wissenschaftliche Zoologie, Band xxxi, 195. 1878. Pl. xiv. The mode of origin observed by Bobretsky in the Lepidoptera does not apparently agree in the later stages with what Weismann has observed in the Diptera, and I have observed in the flea, as there is present a blastem (Weismann) or clear homogeneous layer between the polar cells and the yolk, and afterwards the blastoderm appears, the polar cells still persisting. See Pl. 2, fig. 1–3, Packard's Embryol. Studies on Hexapodous Insects. Memoirs Peabody Academy of Science, 1872. See also Weismann's Entwickelung der Dipteren, Taf. 1, fig. 3.

and then the blastoderm spreads out farther and farther from the upper end of the egg until finally it covers or envelops the whole yolk. This layer of cells is called the *blastoderm.*[122]

As to the origin of the primitive amœboid cells, Bobretsky is in doubt, but is disposed to think that they are the result of the subdivision of the germinative vesicle or nucleus of the ovarian egg-cell. In this connection may be quoted the observations of Graber, who states that an examination of the ovarian cell at an early period has revealed the presence, in the center of the yolk, of a number of amœboid cells, which appear to have been formed by the division of the germinal vesicle. These "primary embryonic cells" have a relatively large nucleus and a number of nucleoli. Several may be seen to unite with one another by means of their pseudopodia, and they may also be observed to undergo division.

The blastodermic disc or primitive band.—After the blastoderm arises, its cells become flat on the dorsal side of the egg, but on a portion of the ventral side become crowded and columnar, *i. e.*, long and somewhat prismatic; this forms what appears to the eye as an oval, or long, narrow, elliptical disk, which is called the *primitive band* or *blastodermic disk.* This is the germ of the future embryo, and from its outer surface the appendages of the future insect arise. At the posterior end of this whitish, riband-like, long-oval disk, "ventral plate," or "primitive band," as it is variously called, appear two folds, with a furrow between them. This is the "germinal groove." The two folds on each side gradually approach, according to Kowalevsky's observations on the development of a beetle (Hydrophilus), and form in the middle and hinder parts of the primitive band a cavity or canal. This invagination-cavity corresponds to the primitive invagination-cavity or primitive hind intestine, or gastrula mouth of the worms and crustacea, as well as vertebrates and other animals.

Origin of the cellular or germinal layers.—This cavity disappears, but the cells forming its walls subdivide, and as the result a new layer of cells is formed beneath the outer original cell-layer or blastoderm. This is called by some authors the mesoderm, by others the endoderm. (The mode of origin of these two layers is in dispute.) At any rate, the primitive band finally splits or subdivides into two and afterwards three layers, which become the ectoderm, mesoderm, and endoderm of the adult animal. In their embryonic stage these layers are called:

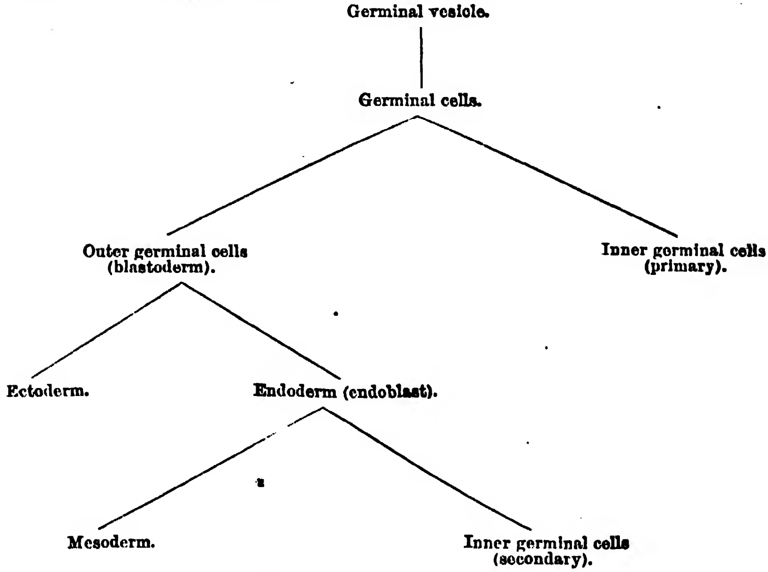
1. Ectoblast (or epiblast).
2. Mesoblast.
3. Endoblast (or hypoblast).

According to Graber the blastoderm subdivides in insects into two layers only, the outer and the inner, while the middle layer (mesoblast) appearing later, always owes its origin to the endoblast.

---

[122] Archiv fur Mikr. Anatomie, xv, 1878, 630. (See also abstract in Quart. Jour. Royal Micr. Society, vol. ii, 1879, p. 413.)

The following diagrammatic view, copied from Graber, will render clearer these statements:



Embryonal membranes.—After the primitive band is formed, the blastoderm twice molts or casts off a layer of cells. The first molt is before the limbs bud out, and is called the outer or *serous membrane.* (Pl. XXII, Fig. 2, *ser.*) It is at first cellular, the nuclei finally disappearing as it stretches and covers the growing embryo. The inner, called the *amnion* (Pl. XXII, Fig. 2, *am*), is more closely connected with the embryo; originally connected with the serous membrane, it splits off from the primitive band about the time the appendages begin to bud out, and continues to closely envelop the body and appendages, as seen in Pl. XXII, Fig. 2. Both of these membranes are, at the time of hatching, cast off with the egg-shell or chorion,[123] and the exochorion or polygonal outer crust which envelops the shell or chorion proper, and which is so well developed in the egg of the locust. Hence we have eight layers in the insect during embryonic life:

1. Exochorion. (Remains of the epithelium of the ovarian follicle.)
2. Chorion. (Egg-shell or cuticle secreted in the ovarian follicle.)
3. Vitelline membrane.(Primary egg-membrane. Yolk-skin)

4. Serous or outer germ-membrane. (Blastodermic molt.)		Derived from the blastoderm.
5. Amnion. Inner germ-membrane. Cast from the primitive band.		
6. Ectoderm.	Embryo.	
7. Mesoderm.		
8. Endoderm.		

[123] For an account of the egg and its outer crust or exochorion, and the mode of hatching, see 1st Report of the Commission, pp. 277, 278.

Division of the embryo or primitive band into body-segments.—Meanwhile the primitive band grows at the expense of the yolk, spreading out more and more over its surface, until (see Pl. XXII, Figs. 1, 2) it lies like a broad riband over the yolk, each end nearly meeting. By this time it becomes divided by transverse impressed lines into segments, which correspond to those of the larva and adult. The first of these segments is divided into two broad and flaring flaps, which are called the procephalic lobes. It becomes the antennal segment; behind this are 16 segments, making 17 in all, or, as in many insects (locust, &c.), which have 11 abdominal segments, there are 18 body-segments, 4 for the head, 3 for the thorax, and 11 for the abdomen.

Development of the appendages.—Nearly if not quite simultaneously all the limbs bud out from each side of the median line of the primitive band. There are never more than one pair to each segment; in some insects there are, as in the Lepidoptera, a pair on each abdominal segment. The three pairs of rhabdites or elements of the ovipositor in bees, grasshoppers, &c., arise in the same manner as limbs. It will be noticed, as seen in Pl. XVII, Figs. 1, 1*a*, that the antennæ, jaws and maxillæ, as well as legs, are alike at first. They acquire their definitive form just before the embryo hatches from the egg.

In some insects, as the flea, the embryo is provided with a temporary knife-shaped process on top of the head, called the egg-shell cutter, for the purpose of splitting open the tough egg-shell that the embryo may escape.

Turning now to the internal changes during the development of the embryo, we have to trace the formation of the digestive cavity, the nervous system, heart, &c. Of the different viscera, the first to appear after the formation of the blastodermic disk or primitive band is the

Nervous system.—This develops in the ectoblast or outer germinal cell-layer. It arises as two cellular strings or cords which split off from the skin. They lie one on each side of the median line of the body. They are enlarged at intervals corresponding to the segments of the body, forming a series of large ganglia, which lie next to each other, and are connected by short strands or commissures. As seen in Pl. XVII, Fig. 2, there are in the locust 15 ganglia, or one to each segment of the body except the mandibular and maxillary segments in the head. The nervous system may be divided into two parts, one the brain, which is præoral, situated in the upper part of the head, while the rest of the system is postoral and lies on the ventral side of the body. In section each ganglion consists at first of nucleated cells, those in the center being more close and dense than those on the outside.

The alimentary canal.—This does not arise at once, the middle portion not being developed until just before the embryo hatches. The alimentary canal in embryo insects is divided into three primary portions. The anterior, called the *stomodæum*, becomes differentiated into the pharynx, œsophagus, crop (ingluvies), and proventriculus of the adult; the pos-

terior, called the *proctodæum*, becomes the anus and rectum. The middle portion of the tract includes the stomach, ending just in front of the urinary tubes, which open into the anterior end of the *proctodæum*.

Pl. XVI, Fig. 1, shows the embryo of the locust with the stomodæum and proctodæum well developed, the middle portion not being yet developed from the yolk. The fore and hind intestine originally arise by inpushings or invaginations of the ectoblast, and they are distinguished by being lined with chitine.

The stomach or *mesenteron* is at first a closed sac independent of the fore and hind divisions of the alimentary tract. It finally touches the opposing ends of the stomodæum and proctodæum; the cellular walls are absorbed, disappear, and just before hatching the digestive canal becomes a continuous hollow tube open from mouth to vent. The exact origin of the mesenteron is not known beyond the fact that the stomach is lined with the endoblast. According to Kowalevsky, in Hydrophilus the mesoblast is concerned in the formation of the stomach. At any rate, the yolk-cells appear to give rise to the endoblastic walls of the stomach (mesenteron).

The coecal or pyloric appendages of the stomach have the same origin as the latter; while the Malpighian or urinary tubes arise, as Dohrn first observed in the embryo mole cricket, and as we shall see in the locust (Pl. XXI, Fig. 6, *ut*), as outgrowths of the ectoblast of the anterior end of the proctodæum.

The origin of the genital glands has not been clearly made out. The polar cells which appear in Diptera before any other cells of the blastoderm, those referred to in the note on p. 263, are supposed to give origin to the ovaries or testes. Dohrn states that in the mole cricket the genital glands arise from the proctodæum. As Balfour states in his "Comparative Embryology," it appears to be fairly clear that the genital glands of both sexes have an identical origin.

The tracheæ and salivary glands.—As may be seen in Pl. XVI, Fig. 1, these arise nearly simultaneously. The tracheæ and stigmata arise as invaginations of the ectoblast; the stigmata are the original or primitive cavities caused by the ingrowth of the walls of the primitive band, and there is a pair to each segment, the head-segments (except the antennal) perhaps not excepted. The three thoracic and first eight abdominal segments are provided each with a pair of stigmata. The blind ends of the tubes unite in the locust to form on each side a dorsal and ventral longitudinal main trachea.

The salivary glands (Pl. XVI, Fig. 1, *sal*), are said to be ectoblastic invaginations, and to be formed in the same general manner as the tracheæ; they are not invaginations of the stomodæum, but, as Balfour states, arise from the primitive band behind the mouth on the inner side of the mandibles.

The spinning glands of caterpillars and of bee larvæ (Apis) arise in the same way, but are situated on the inner side of the first maxillæ.

Development of the wings.—As has been shown by Weismann, the wings of flies are indicated late in larval life. They arise from minute masses of indifferent cells called "invaginal disks," these being microscopic internal bodies attached to some nerve or tracheal branch.

The mode of origin of the wings may, however, be best understood by observing the early stages of those insects, such as the Hemiptera, Orthoptera, and Pseudoneuroptera, which have an incomplete metamorphosis. If the student will examine Plates I–III of the First Report of the United States Entomological Commission, particularly Figs. 1, 2, 3, he will see that the wings in the locust arise as simple expansions downward and backward of the lateral edges of the meso- and metanotum. In the second larval stage this change begins to take place, but it does not become marked until the first pupal stage, when the indications of veins begin to appear, and the lobe-like expansion of the notum is plainly enough a rudimentary wing. This mode of development of the wings in Orthoptera has been shown and well illustrated by Graber,[124] who first drew attention to this mode of development of the wings, and showed that it is common to all Orthoptera. Ignorant of his paper, we had arrived at the same result, after an examination of the early pupal stages of the cockroach, as well as the locusts, of Termites and various Hemiptera. In all these forms it is plainly to be seen that the wings are simply expansions, either horizontal or partly vertical (when as in locusts, &c., the body is compressed, and the meso- and metanota are rounded downwards), of the hinder and outer edge of the meso- and metanotum. As will be seen by reference to Plates I–II of our First Report, and by the accompanying figures, the wings are notal (tergal) outgrowths from the dorsal arch of the two hinder segments of the thorax. At first, as seen in the young pupal cockroach (Pl. LXII, Fig. 1) and locust, the rudiments of the wings are continuous with the notum. Late in pupal life a suture and a hinge-joint appear at the base of the wing, and thus there is some movement of the wing upon the notum; finally, the tracheæ are well developed in the wings, and numerous small sclerites are differentiated at the base of the wing, to which the special muscles of flight are attached, and thus the wings, after the last pupal molt, have the power of flapping, and of sustaining the insect in the air; they thus become true organs of flight.

It is to be observed, then, that the wings in all ametabolous and hemimetabolous insects are outgrowths from the notum, and not from the flanks or pleurum of the thorax. There is, then, no structure in any other part of the body with which they are homologous.

The same may be said of the true Neuroptera, the Coleoptera, and the Diptera, Lepidoptera, and Hymenoptera. As we have observed in the house fly,[125] the wings are evidently outgrowths of the meso- and meta-

[124] Zur Entwickelungsgeschichte und Reproductionsfähigkeit der Orthopteren. Von Vitus Graber. Sitzungsberichte d. math.-naturw. Classe der Akad. d. Wissensch., Wien. Bd. lv, Abth. i, 1867.

[125] On the Transformations of the Common House Fly, by A. S. Packard, jr. Proceedings Boston Society of Natural History, vol. xvi, 1874. See Pl. 3, Figs. 12*a*, 12*b*.

notum; we have also observed this to be most probably the case in the Lepidoptera, from observations on a Tortrix in different stages of metamorphosis.[126] It is also the case with the Hymenoptera, as we have observed in bees and wasps;[127] and in these forms, and probably all Hymenoptera, the wings are outgrowths of the scutal region of the notum.

With these facts before us we may speculate as to the probable origin of the wings of insects. The views more generally proposed are those of Gegenbaur, also adopted by Lubbock[128] and originally by myself.[129] According to Gegenbaur:[130]

> The wings must be regarded as homologous with the lamellar tracheal gills, for they do not only agree with them in origin, but also in their connection with the body, and in structure. In being limited to the second and third thoracic segments they point to a reduction in the number of the tracheal gills. It is quite clear that we must suppose that the wings did not arise as such, but were developed from organs which had another function, such as the tracheal gills; I mean to say that such a supposition is necessary, for we cannot imagine that the wings functioned as such in the lower stages of their development, and that they could have been developed by having such a function.

The foregoing statements are, however, inexact. If we examine the tracheal gills of the smaller dragon-fly (Agrion), or the May flies, or Sialidæ, or Perlidæ, or Phryganeidæ, we see that they are developed in a very arbitrary way, either at the end of the abdomen, or on the sternum, or from the pleurum; moreover, in structure they invariably have but a single trachea, from which minute twigs branch out;[131] in the wings there are five or six main tracheæ (Fig. 3), which give rise to the veins. Thus, in themselves, irrespective of their position, they are not the homologues of the gills. The latter are only developed in the aquatic representatives of the Neuroptera and Pseudoneuroptera, and are evidently adaptive, secondary, temporary organs, and are in no sense ancestral, primitive structures from which the wings were developed. There is no good reason to suppose that the aquatic Pseudoneuroptera or Neuroptera were not descendants of terrestrial forms.

To these results we had arrived by a review of the above-mentioned facts, before meeting with Fritz Müller's opinions, derived from a study of the development of the wings of Calotermes. Müller[132] states that "(1) The wings of insects have not originated from 'tracheal gills'. The wing-shaped continuations of the youngest larvæ are indeed the only parts in which air tubes are completely wanting, while tracheæ are richly developed in all other parts of the body. (2) The wings of insects have

---

[126] Compare also the work of H. Landois on the origin of the wings in Lepidoptera. In the rudimentary minute wings there are at first six tracheal branches corresponding to the six primary veins of the wing. See Siebold and Kölliker's Zeitschrift, Bd. xxi, Pl. xxiii, 1871.

[127] See our Guide to the Study of Insects, p. 66, figs. 65, 66.

[128] Origin and Metamorphoses of Insects, 1874, p. 73.

[129] Our Common Insects, 1873, p. 171.

[130] Elements of Comparative Anatomy, English translation, p. 247.

[131] Compare the observations of Palmèn, Gerstäcker, Vayssière and others.

[132] Beiträge zur Kenntniss der Termiten. Jenaische Zeitschrift für Naturwissenschaft, Bd. ix, Heft 2, p. 253, 1875. Compare, however, Palmèn's Zur Morphologie des Tracheensystems, Helsingfors, 1877, wherein he opposes Müller's view and adopts Gengenbaur's. See p. 8, foot note.

arisen from lateral continuations of the dorsal plates of the body-segments with which they are connected."

Now, speculating on the primary origin of wings, we need not suppose that they originated in any aquatic form, but in some ancestral land insect related to existing cockroaches and Termes. We may imagine that the tergites (or notum) of the two hinder segments of the thorax grew out laterally in some leaping and running insect; that the expansion became of use in aiding to support the body in its longer leaps, somewhat as the lateral expansions of the body aid the flying squirrel or certain lizards in supporting the body during their leaps. By natural selection these structures would be transmitted in an improved condition until they became flexible, *i. e.*, attached by a rude hinge-joint to the tergal plates of the meso- and metathorax. Then by continued use and attempts at flight they would grow larger, until they would become permanent organs, though still rudimentary, as in many existing Orthoptera, such as certain Blattariæ and Pezotettix. By this time a fold or hinge having been established, small chitinous pieces inclosed in membrane would appear, until we should have a hinge flexible enough to allow the wing to be folded on the back, and also to have a flapping motion. A stray tracheal twig would naturally press or grow into the base of the new structure. After the trachea running towards the base of the wing had begun to send off branches into the rudimentary structure, the number and direction of the future veins would become determined on simple mechanical principles. The rudimentary structures beating the air would need to be strengthened on the front or costal edge. Here, then, would be developed the larger number of main veins, two or three close together, and parallel. These would be the costal, subcostal, and median veins. They would throw out branches to strengthen the costal edge, while the branches sent out to the outer and hinder edges of the wings might be less numerous and farther apart. The net-veined wings of Orthoptera and Pseudoneuroptera, as compared with the wings of Hymenoptera, show that the wings of net-veined insects were largely used for respiration as well as for flight, while in beetles and bees the leading function is flight, that of respiration being quite subordinate. The blood would then supply the parts, and thus respiration or aëration of the blood would be demanded. As soon as such expansions would be of even slight use to the insect as breathing organs, the question as to their permanency would be settled. Organs so useful both for flight and aëration of the blood would be still further developed, until they would become permanent structures, genuine wings. They would thus be readily transmitted, and being of more use in adult life during the season of reproduction, they would be still further developed, and thus those insects which could fly the best, *i. e.*, which had the largest wings, would be most successful in the struggle for existence. Thus also, not being so much needed in larval life before the reproductive organs are developed, they would not be transmitted

except in a very rudimentary way, as perhaps masses of internal indifferent cells (imaginal disks), to the larva, being the rather destined to develop late in larval and in pupal life. Thus the development of the wings and of the generative organs would go hand in hand, and become organs of adult life.

It is not improbable that the metamorphoses in insects were primarily due to the acquisition of wings, and that the latter were likewise primarily due to the ripening of the sexual organs. We see that in Orthoptera, Blatta especially, the larvæ only differ from the adult in wanting wings and in having undeveloped genital organs. Metamorphosis, then, in insects, is correlated most intimately with the presence or absence of wings. Moreover, the differentiation of the meso- and metanotum is closely dependent on the presence of wings. Wherever the wings are wanting the scutum, scutellum, &c., are not differentiated.

The next step above the Orthoptera are the Pseudoneuroptera, such as Perlidæ, Psocidæ, and Termitidæ; and finally the Odonata and Ephemeridæ. In all these forms the metamorphosis is incomplete, the chief difference between the larva and adult being the presence of wings and of ripe ovaries and testes. So it is with the Hemiptera.

When we ascend to the true Neuroptera we see a greater difference between the larva and the imago, and a third, *i. e.*, quiescent pupal stage. Here adaptive characters come in. The caddis worms, possibly derived from Sialid forms, and constructing tubular cases, acquired cylindrical instead of flattened bodies; rapidly feeding up, they, by some means, acquired the habit of resting in closed cases, and during this quiescent period the wings and genital organs would become prematurely developed, until, as soon as the pupal sleep was ended, the sexual powers being ripe, the wings would suddenly attain their full development, and the insect, the caddis fly, for example, would both sexually and as regards powers of flight become highly active.

Given a few cases of complete metamorphosis in the Neuroptera, especially Phryganeidæ and Sialidæ, we can explain the origin of a metamorphosis in the higher orders. As the Coleoptera have probably descended from lost forms resembling the Sialid Neuroptera, and the Lepidoptera and Trichoptera from a common stock, the Diptera and Hymenoptera being also probable offshoots from the primitive Lepidopterous stock, it is easy to see how the majority of insects which belong to the metabolous orders should all have a complete metamorphosis, this being secondary and adaptive in its nature.

THE EMBRYOLOGICAL DEVELOPMENT OF ORTHOPTEROUS INSECTS.

In order to elucidate the earliest steps in the development of the locust, so as to complete far as possible our knowledge of the natural history of the locust, as well as to examine the embryology of a typical orthopterous insect, the following researches were undertaken. The results are imperfect and fragmentary, as it was not easy

to obtain full series of eggs laid from the time of oviposition to that of hatching. Our examination of eggs confirms what Mr. Riley had previously stated, that the young develop in the autumn, though most of them delay hatching until the spring. From our observations, it appears that the embryo locust begins to develop as soon as the eggs are impregnated, this act taking place, as well known, during oviposition in the soil. The embryo, probably, passes through the earlier and indeed nearly all the embryonic stages before winter sets in; the embryo being nearly or quite ready to hatch probably within a month after the eggs are laid. It is therefore not surprising that a few unusually warm days in November or early December may cause an acceleration in the development of the embryo, and that young locusts should then hatch, while the majority of young do not hatch until the following spring.

The only observations, so far as we are aware, on the embryology of any orthopterous insect, are those of Dr. Anton Dohrn, on some stages in the development of the European mole cricket, published in Siebold and Kölliker's Zeitschrift für wissenschaftliche Zoologie, xxvi, 1876 (with no illustrations).

In this paper Dr. Dohrn showed that in Gryllotalpa, or the mole cricket, the primitive streak incloses the yolk. On the sides and at each end the primitive band is continued into a membrane, which passes around it and envelops the embryo; this is the amnion. The serous membrane is likewise present and seems to be united with the amnion into one membrane.

The position of the embryo at this time is such that the head begins at the middle point of the back part of the egg, the mouth appendages on the anterior pole, the ventral segments on the ventral side, and the anus now is situated on the hinder pole of the egg.

In this position and when the appendages have already reached a considerable size, Dohrn noticed the first appearance of motion in the embryo. This consists of slight contractions of a thin membrane.

Dr. Dohrn observed how both leaves of the embryonal skins are united before the head, how their cells undergo a fatty degeneration, how the skin becomes thinner and more transparent, and how in other parts of the membrane a kind of streak-formation sets in, while the cells seem arranged in rows. At the same time the whole membrane, which until now has laid directly against the inner egg-membrane, is seen to continuously contract, so that, finally, the entire interspace which separated it from the embryo, especially on the fore body, disappeared, while the appendages which extended out free into this space were, by the pressure of the embryonal skins, pressed into the primitive band, so that they were not to be seen. Shortly the whole embryo lay like a ball within the egg-skins.

The digestive canal of insect-embryos consists of three portions: fore, middle, and hind gut. The formation of these three parts does not take

place at the same time and in the same way, the fore and hind gut forming first and simultaneously, by an invagination of the outer germ-layer (*ectoderm* or *ectoblast*) while the cells of the mid-gut, as Dohrn states, arise directly from the yolk. The resorption of the food goes on in the mid-gut, the results of digestion passing through the walls of this part of the intestinal tract to mix with the circulatory fluid or blood. On the other hand, the function of the hind gut is that of an urinary bladder, since the Malpighian vessels open into it. Dohrn confirms Bütschli's observations made on the embryo of the honey bee, that the urinary or Malpighian vessels arise from the outer germ-layer.* Like the Malpighian tubes, the salivary glands and the tracheæ are offshoots of the ectoblast, as shown by Bütschli. Likewise, as shown by Ganin, Dohrn claims that the ovaries arise from the hind gut, which it will be remembered is an invaginated portion of the ectoblast.

For the cutting and mounting of the sections of locust eggs which I studied, I am indebted to Mr. Norman N. Mason, of Providence, R. I.

I. *Development of Caloptenus atlanis.*

The earliest stage observed was in a mass of eggs of *Caloptenus atlanis* Riley, which were sent me from Missouri by Prof. C. V. Riley, with the label "eggs of *C. atlanis*, laid 10 days." These eggs were laid in the autumn, and the embryos, as seen by the following account, were already far advanced, the body-segments and appendages having appeared, the eyes being indicated, the brain and nervous cord being well formed, and the œsophagus and crop (stomodæum) and hind gut (proctodæum) being indicated, so that the embryos had probably nearly reached the stage represented by Pl. XVI, Fig, 1, of *C. spretus*.

This shows that development in the eggs of those locusts which deposit their eggs in the autumn goes on rapidly, and that the embryo is nearly perfectly formed and about ready to hatch in the early autumn. As is well known, some locusts (*C. spretus*) do hatch in the late autumn in mild weather, while the rule is that the young hatch out in March and April. At all events, it is proved by finding the embryos so far advanced ten days after oviposition, that development begins as soon as the eggs are deposited, and that the embryo is nearly perfected and about ready to hatch, until the approach of winter arrests the final stages of development of the embryo, a few warm days in spring enabling it to complete its growth and to hatch.

The drawings on Plates XX and XXI represent the earliest observed stages of *Caloptenus atlanis;* it having been impossible to obtain the freshly-laid eggs of *Caloptenus spretus* within the last two or three years, owing to the general scarcity of the locust and of local observers who could collect them. To observe any earlier stages than those figured it would be necessary to secure the eggs as soon as laid, and then to place examples of them in alcohol or in hardening fluid, according to

Bobretsky's method, at intervals of a day until, say, the expiration of ten days.

The specimens were preserved in alcohol of ordinary strength, not having been hardened by any reagent, such as chromic acid, and the sections were cut by Mr. N. N. Mason, of Providence, who, after having hardened the eggs in absolute alcohol, then placed them in dissolved gum arabic, having previous to cutting stained the eggs in picro-carmine.

The embryo was cut into thirty-four sections, some of them passing through the limbs (see Pl. XX, Fig. 1), which shows that the procephalic lobes, the mouth parts and legs had been indicated, and that the embryo was nearly as far advanced as that represented on Pl. XVI, Fig. 1.

Nervous system and eyes.—At this time the nervous system is well developed, the brain being now nearly as large in proportion to the head and to the succeeding segments as in the nearly mature larvæ figured in the chapter on the brain of the locust in the Second Report of the United States Entomological Commission, Plate XII. At this time, as seen in Pl. XX, Fig. 1, the two hemispheres of the brain (*br*) are indicated, but there are as yet no signs of a differentiation of the brain into the cerebral lobes and antennal lobes of the advanced embryo figured on Pl. XII of our Second Report.

The optic ganglia (Fig. 1, *op. g.*) are large, and, like the brain, composed of minute ganglion-cells. The subœsophageal ganglion is now about twice as large as those of the ventral cord. A section of one of the thoracic ganglia is represented on Pl. XIX, Fig. 3.

The eyes are now clearly indicated and of comparatively large size (Pl. XX, Fig. 1). The rows of cells radiating outward from the periphery of the optic ganglion are well indicated, showing that at this date and probably at an earlier period the separate divisions, or those corresponding to the simple eyes, are indicated. The eyes of the embryo of *C. spretus* at a later date are represented at Pl. XVI, Fig. 4, when the cones and rods are clearly developed.

The heart is now well developed (Pl. XX, Figs. 3 and 4), and from what we have seen, as indicated in Fig. 4, the mode of origin is as claimed by Dohrn. As seen by the section represented by Fig. 4, the walls of the heart at this time are formed of a continuation of the amnion which merges into the walls of the heart. The membrane forming the heart is formed beneath and above of a single row of epithelial cells, which on the sides become double, or, as seen on the right side of the figure, about four rows deep. From this it would appear that the view of Dohrn that the heart originates as a loop of the ectoblast, which becomes constricted and finally forms a separate tube, is a more correct one than the opinion of Kowalevsky that it is formed by the union of what were originally independent mesoblast-cells. The contents of the heart are very finely granular, the granules as a rule not much if any larger than those in the small cells forming the amnion or

the cellular wall of the heart itself. No nuclei could be detected among these granules.

The tracheæ.—The tracheal system at this period could not with certainty be made out in our sections, although, as will be seen, the urinary or Malpighian tubes are clearly indicated. Only two or three sections (Fig. 3 *tr*) show clearly what, judging from Hatschek's figures, we suppose to be a section of a main tracheal tube. This section is evidently through one of the anterior segments of the thorax as it passes through a pair of legs (*l*). But in the sections posterior to this, especially the abdominal one, the organ which we judge to be the trachea does not reappear, nor are there any indications of sections of smaller tracheal tubes to be found, unless the circle of cells in the section of the leg (Fig. 3, *tr ?*) be such, though the preparations are good enough to show them if they were present. The body or organ which I provisionally regard as the first indication of the main lateral trachea (Fig. 3 *tr* and 3 *a*) lies outside of the yolk, and is clearly the result of an invagination of the ectoblast. It is situated directly above the insertion of the limb (*l*), at the place where we should naturally look for the first indications of the trachea. Its structure at this period, as seen in Fig. 3*a*, is nearly the same as in the Lepidoptera (compare Hatschek's Taf. II, Fig. 3 *tr*), there being an outer layer of cylindrical epithelium, with often large nuclei, while the cylindrical cells are replaced by an inner mass of polygonal cells.

The digestive canal.—At this period the two extremities of the digestive canal have been formed by the infolding or invagination of the ectoblast (epiblast). It will be remembered that the first section of the canal, which becomes in the adult the mouth, œsophagus and crop, is in the embryo called the *stomodæum;* and the third section, corresponding to the rectum and intestine, is called the *proctodæum.* In the first section through the brain and eyes the microtome passed through a portion of the *stomodæum.* It is seen to be composed of the usual two sub-layers, the inner or glandular (Darmdrüsenlage) and the outer (Darmfaserlage) or fibrous layer.

Turning now to the *proctodæum* (compare Pl. XXI, Fig. 8, 8*a*), showing the first and third sections of the digestive tract at a little later stage, while the middle section or future stomach (mesenteron) is undeveloped), Figs. 6–9 represent different sections through the proctodæum, which is a short thick tube, with the glandular and fibrous layer already developed. Fig. 6 passes through the anterior end, and Fig. 8 through the rectum and anus. Fig. 8 shows clearly the primitive opening into the rectum, the ectoblast having grown or pushed in from the hinder end of the blastoderm, the ends of which are cut through, as seen in Figs. 7, 8, 8 *a*, 9 *bl.* The glandular layer, composed of columnar epithelium, is seen to be completely formed, while the polygonal cells of the fibrous layer are seen to be splitting off or separating from the original ectodermal layer. The latter is seen to be continuous with the amnion (*am*); the double rows of

the glandular layer finally becoming a single row of amniotic cells which pass up dorsally towards and finally appear to surround a cavity (*do?*) which may possibly be the remnants of the "dorsal plate" of Kowalevsky and Dohrn (see Balfour's Comparative Embryology, i, p. 335, Fig. 185. Our sections are here imperfect, leaving a doubt in my mind whether the organ (*do?*) is not formed by a growing up of the ectoblast, as Dohrn states, towards the dorsal region, forming a provisional tube. It is doubtful whether at this stage the heart reaches as far back as the proctodæum; and the sections in front (Figs. 3, 4, 5) show the heart very clearly, with a thick, definite wall, and situated next to the serous membrane. On the other hand, the tube-like organ (*do?*) is less glandular, with much thinner walls than indicated by Kowalevsky's figures.

The urinary tubes.—At this stage the urinary or Malpighian tubes are clearly indicated (Fig. 6 *ut*) as arising from the anterior end of the incipient intestine or proctodæum. In the section represented by Fig. 6, the microtome passed through the end of the proctodæum, in which the two sub-layers, the inner or glandular (*gl*) and the outer or fibrous (*fl*), are clearly indicated, the origins of at least eight, and possibly ten, of these tubes were observed. It will be remembered that the primitive number of urinary tubes is four. According to the observations of Dohrn, these tubes develop from two primitive pairs of tubes from the proctodæum. Hatschek, Taf. III, Fig. 7, shows the mode of origin by budding of the secondary tubes from the primary ones. The urinary tubes are plainly seen to be hollow; they are now quite long, as long pieces are seen cut off and lying about in different places in the section, and the microtome also passed through them in section, as seen at *ut'*. Their origin from the glandular layer of the primitive intestine is not clearly seen at this stage, as, judging by one section, there is not seen to be any close connection at this period with the inner or glandular sub-layer of the proctodæum.

No traces of the sexual glands, that I could discover, appear at this stage.

The yolk cells.—At the period represented by Figs. 3 and 5 (Pl. XX), there is seen to be a very fine net-work of irregular, angular, very minute masses of protoplasm, which spread through the yolk-mass. In some of the triangular masses a minute nucleus-like body not much larger than the granules is to be seen.

In close relation with this singular net-work of protoplasm inclosing the colossal yolk cells, and which stains a delicate red with picro-carmine, are large, usually rounded masses of protoplasm. They are not, however, well-developed cells, but may rather be compared with the nuclei of cells. Some of them appear to possess a minute nucleolus. We regard these as nuclei of the yolk cells, each yolk cell containing from about six to eight of them.

Figure 5 *a* represents a portion of a yolk-ball with its protoplasmic wall,

enlarging into amœbiform or triangular masses at the corners between the polygonal yolk-balls. From these thin walls fibers are sent off to the rounded nuclei within, with which are also associated scattered angular masses (*an*). We judge from these two sets of bodies, the rounded and the amœbiform, that the nuclei of the yolk cells are in an active state of proliferation.

A peculiarity in the relation of the yolk granules to one another we have never seen mentioned. They appear to be attached to the yolk-cell-wall by very slender pedicels or fibers, sometimes as many as five or six such fine strings or fibers holding the larger granules in place; while those granules in the interior of the yolk cell are attached to each other by slender fibers. The granules are more numerous in the center of the yolk cell than near the periphery. These fibers, like the granules themselves, are not stained by picro-carmine; the yolk granules are also colorless, not receiving a stain, being filled with a clear fluid, and are not sufficiently numerous to be crowded together, hence they retain their original spherical form.

We were unable in our sections of *C. atlanis* to detect any entoblastic or mesoblastic cells, either free in the yolk or in layers.

II. *Development of Caloptenus spretus.*

I received in the winter of 1881 a mass of eggs taken from the earth at Nephi, Utah, January 7, which had been deposited the previous autumn. They were kept in a sunny room heated from 60° to 70° F.

Plate XVII, Fig. 1, 1 *a* represents the earliest stage (observed January 26, 1881). At this time the embryo lay on one side of the yolk, but not immersed in it, the primitive segments decreasing in size from the procephalic lobes to the end of the abdomen. The embryonal membranes are not indicated in the figures. The procephalic lobes are nearly as long as deep, and the eyes are already indicated. The head is seen to be composed of two regions, the procephalic lobes, and the tergal portion of a second segment. This segment we are disposed to regard as the fourth (second maxillary or labial), and it may be compared with the very distinct fourth cephalic arthromere of Diplax,[133] a dragon fly. Of the three thoracic segments the last is rather longer than the others.

Plate XVI, Fig. 1 (observed January 28), represents a more advanced embryo, which had been removed from the egg and slipped out upon the surface of a live-box. The nervous system, consisting of the brain and succeeding ganglia, is now clearly indicated, as are also the tracheal system and spiracles.

As regards the nervous system, the brain and optic ganglia are indicated; the eyes begin to show a reddish tint. The ganglia of the ventral chain are 14 or 15 in all, including the brain, as better seen in Pl. XVII, Fig. 2, than in the present figure. Thus there are two ganglia in the

[133] Embryological Studies on Diplax, Perithemis, and the Thysanurous genus Isotoma. By A. S. Packard, jr. Memoirs Peabody Academy of Science, 1871. Pl. 2, Fig. 9,[4].

head: one in each thoracic segment, and one in each of the ten abdominal segments.

There are two main tracheal stems indicated at this date, the tracheæ at this time consisting of masses of yolk globules. In nearly each segment are smaller connecting branches, while small branches pass outward from the outer tracheal stem (*tr'*) to the stigmata. No branches were traced into the head, and the two main trunks appeared to be united in the fourth cephalic segment, where they expand, and at the end of the abdomen they unite in the ninth segment. The stigmata were small, with a central depression, the area of invagination.

The most interesting feature at this stage is the primitive mouth or œsophagus and fore-stomach or *stomodæum* (*st*). This is seen to be a sac, the result of invagination, and it has a double wall, with the square mouth opening at the anterior end. The notch behind the mouth may possibly be the point where the rudimentary proventriculus begins. The primitive intestine or *proctodæum* (*pr*), has the same structure apparently as the *stomodæum*. There was no appearance at this stage of a mid-gut or mesenteron. At the back part of the head was a mass of yolk cells extending from near the posterior part of the stomodæum outwards towards the outer edge of the mandibular segment. This mass of cells (Fig. 1, *sal*) I am disposed to regard as the first indications of the salivary glands.

Pl. XVIII, Fig. 3, represents the fore-head or pre-oral part of the head of another embryo, with the eyes a little more advanced, and showing the anterior ocellus (*oc*) and the œsophageal part of the stomodæum.

Pl. XVI, Fig. 2, shows the structure of the body walls, being the epithelium forming the integument of the side of a segment, formed by a single row of oval epithelial cells. Fig. 3 represents the structure of the inner embryonal membrane or "amnion," some of the blastoderm cells being distinctly nucleated.

February 2. A more advanced embryo was observed in process of turning. Pl. XVIII, Fig. 2, represents the head and thorax at this time. The eyes are now reddish and far advanced. The three ganglia succeeding the brain are also to be seen.

In an embryo observed February 5,—perhaps, however, not so far advanced as the preceding,—the structure of the eyes could be observed. Pl. XVI, Fig. 4, is a natural section through the eye as seen in the living embryo. The cones are seen to be oval-oblong cells, with a distinct nucleus; each cone is succeeded by the rod, and at a short distance from the cone is the indication of the retina (*ret*), a reddish mass not continuously extended from rod to rod, each mass with a dark distinct nucleus.

The origin of the ocelli is now to be seen. Pl. XVI, Fig. 5*e*, represents a vertical view of the procephalic lobes, with the indications of the three ocelli. Each ocellus is seen to be formed of several (6 or 7) reddish pigment cells. Pl. XVIII, Fig. 4, shows clearly the relations of the antennæ

to the procephalic lobe, which is plainly seen to form the pleura of the first or antennal segment (arthromere), the antenna being developed from the sternal side, and the eye developed on the tergal side. This preparation shows clearly (1) that the procephalic lobes are the pleural portion of the first cephalic or antennal segment; (2) that the antenna is an appendage or outgrowth of the procephalic lobes; (3) that the eyes are a specialized group of epidermal cells of the upper part of the procephalic lobes, and are not homologues of the antennæ or of the appendages in general; and (4) it seems to follow from a study of the relations and mode of development of the clypeus and labrum, that they arise between the procephalic lobes, and probably represent the tergal part of the antennal or first cephalic segment, forming the roof of the mouth, *i. e.*, closing in from above the pharynx.

The form of the brain and ganglionic chain is well seen in an embryo observed February 22 (Pl. XVI, Fig. 1). All the ganglia, from the brain to the last pair, are seen to have a group of ganglion-cells in the center, the periphery being free from them; the origin of the main nerves for each ganglion, and also the relations of the ganglia to the body-segments, were clearly seen in this embryo in life. It appears that there are 15 pairs of ganglia, including the brain; *i. e.*, two pairs for the head, one for each thoracic and abdominal segment.

Pl. XVIII, Fig. 1, drawn from an embryo observed February 23, shows the relations of the mandibles, first maxillæ, and second maxillæ or labium. The mandibles remain single-lobed; but in the maxillæ, which were, as seen in Pl. XVII, Fig. 1, 1*a*, single-lobed, two if not three lobes appear, the outer being considerably the larger. The second maxillæ also have subdivided into two lobes, the outer or labial palpi also the larger. It thus appears that the peripheral or terminal parts, ligula, palpiger, and palpus, are formed before the submentum and mentum; these being the result of the consolidation of the second maxillæ; this takes place only shortly before hatching.

The relations of the cephalic appendages were best seen in the embryo represented on Pl. XVII, Fig. 3, and drawn February 15. In this specimen the first maxilla is seen to be divided into three equal lobes, and situated on the outer side of the mandible, while the unequally bilobed second maxilla is situated just external to the end of the antenna.

At this time also the hind limbs are decidedly larger than the two anterior pairs, and the hind femora are now large and thick, while the three main divisions of the legs are clearly indicated.

In the oldest embryo, observed March 12, the limbs are in about the same state of development, and the tracheæ are but slightly more developed than when first observed.

Sections of embryo about ready to hatch.—Pl. XIX, Figs. 1–4, represents sections of the same embryo as in part figured in our Second Report, Plate XII, the sections of the head only being there represented.

III. THE DEVELOPMENT OF THE BARK-BORING BEETLES HYLURGOPS AND XYLEBORUS.

Two Scolytid or bark-boring beetles were observed in abundance, May 30, 1882, near Providence, under the bark of white pines (*Pinus strobus*), engaged in reproduction and egg-laying. The larger of these was *Hylurgops pinifex* Fitch; the smaller *Xyleborus cœlatus* Eich.[134] Bringing specimens to my house, the next day I was able to observe their habits more closely. The following notes refer entirely to *X. cœlatus*. The female was in her hole, the end of her abdomen extending straight up out of the perpendicular hole or "mine;" a male approached her and rubbed the end of her body with his fore pair of feet, the female apparently responding by moving back and forth in her mine. After a moment or two the male visited another female in her hole, and caressed her in the same manner, then returned to the first female and inserted his intromittent organ in the female, the end of whose body was depressed, so as to leave a space between it and the end of the elytra. Union continued for six minutes, during which time the hindermost pair of feet of the male kept stroking the end of the abdomen of its mate, while its antennæ were vigorously moving. At the end of this time it immediately withdrew and disappeared down another hole, the female descending her mine. From these facts we infer that the male of this species is polygamous.

While boring, at least in confinement, the borings or dust is thrown out around the mouth of the mine in a heap. The mine or tunnel is from an inch to an inch and a quarter long; at close intervals on one side there are lateral, deep notches in which two to three or four eggs are irregularly laid; or the eggs are carefully deposited side by side; the lateral notches are then filled with borings or dust by the movements of the female in her main tunnel, the eggs being enclosed in the mass of borings.

Hylurgops does not make lateral notches, but places her eggs side by side in a single recess on one side of the mine.

Pl. XXII, Fig. 1, represents the egg of the Xyleborus 24 hours after impregnation. The primitive band (*pb*) has completely formed, as well as the serous membrane; the primitive band lies outside of the yolk and at this time the segments are not indicated.

Fig. 2 represents another egg observed June 1st. The segments are now clearly indicated, and those of the head (a^1–a^4) are as clearly indicated as those of the future thorax (a^5–a^7) or those of the abdomen (1–8). The dotted portion represents the blastoderm, while the clear lobe-like portions are the appendages, 1–4 the four pairs of appendages of the head, and I–III the three pairs of legs. The amnion (*am*) or inner membrane is now entirely formed; the cells much smaller than those of the outer or serous membrane (*ser*).

[134] I am indebted to the kindness of Dr. G. H. Horn for the identification of this species.

A feature we have observed in these eggs, which are very transparent, is the protoplasmic threads (*th*) which connect the cells of the amnion with one or two of those of the serous membrane. These are also seen in Fig. 2*a*. They appear usually to be forked after originating from the amniotic cells. I have never seen these threads before, nor have they been noticed by embryologists, so far as I am aware.

Fig. 3 is a dorsal view of the embryo, representing the procephalic lobes, or two sides of the epicranium or head; the clypeus in Fig. 2 (*cl*) is seen to be a lobe projecting over the antennæ (*ant*).

(Fig. 4, drawn by Dr. Gissler, represents a farther advanced stage, in Hylurgops, the end of the abdomen (*ab*) having retreated from the back of the head.)

Fig. 5 represents an embryo Xyleborus, observed June 3d. The head is now distinctly differentiated from the rest of the body; the indications of the head-segments have disappeared, the four pairs of appendages (1–4) being clearly indicated, as well as the clypeus (*cly*). In this embryo the indications of eleven pairs of spiracles were observed (sp^1–sp^{11}), and it is interesting to note that in each thoracic segment there is at first a pair of spiracles, though the prothoracic pair is the largest and best developed. The spiracles are superficially composed of a circle of ectodermal cells, which surround a depression of tubes, resulting from a local inpushing or invagination of the ectoblast. Whether the double series of granules (*tr*), which appear to originate from the stigmata, are the germs of the tracheæ or not, we were unable to definitely state, but I am inclined to think that they are.

The presence at first of three pairs of thoracic embryonic stigmata is a matter of great interest, because, as seen in Figs. 8 and 9, the late embryo or freshly hatched larva has but a single pair of stigmata, *i. e.*, those situated in the prothorax. Now it is difficult to explain the presence of these temporary, embryonic, mesothoracic and metathoracic stigmata, unless the ancestors of these and other insects had them in each segment of the thorax. In this connection we may refer the reader to our article on the primitive number of spiracles in winged insects, published in the *American Naturalist*, vol. 8, Sept. 1874, in which we took the ground that the normal, primitive number of pairs of spiracles is eleven, and that probably the larvæ of the different groups of winged insects had originally a pair on each thoracic segment.

The remaining figures were drawn by Dr. C. F. Gissler, and represent the later stages of the embryo Hylurgops. In Fig. 7 the mouth-parts are elaborated, the labial and maxillary palpi being differentiated.

Fig. 8 represents a freshly hatched Hylurgops, which is 1.5 ^{mm} in length. The head is very large, while the spiracles are distinct, and the stomach (*st*), intestines (*i*), and rectum (*r*) are distinctly visible. It will be seen that the rudimentary feet of the early embryo have disappeared. When the larvæ hatch, as soon as they are free from the shell, according to Dr. Gissler's observations, they attach themselves to the surface of the bark

in the manner seen at Fig. *a*, and turn around for half an hour before beginning to feed. Fig. 9 *b* represents one of these larvæ at this time. Fig. 10 was drawn by Dr. Gissler to represent the end of the body of one of these larvæ, to show the form of the infra-anal sucker-like extremity of the last abdominal segment, which is produced and soft at the end, with perhaps temporary dermal glands to secrete an adhesive fluid. The anus is seen to project above and beyond this sucker, *r* representing the rectum, *i* the intestine, and *st* the pyloric end of the stomach.

The general mode of development of these two Scolytid beetles exactly agrees with that of the Curculionidæ or true weevils, as described and figured in the author's note on the development of *Attelabus rhois* in his Embryological Studies on Hexapodous Insects.[135]

IV. THE NUMBER OF SEGMENTS IN THE HEAD OF WINGED INSECTS.

By a study of the structure of the head of adult insects it is very difficult, if not impossible, to determine the number of segments in the head of winged insects. The number as given by different authors is very variable, while it is popularly supposed that the head corresponds to a single segment, and that the different pieces are simply "subsegments." We will quote from Newport, article *Insecta*, in Todd's Cyclopædia of Anatomy and Physiology, the views generally entertained on this subject.

"According to the investigations of the most careful observers, Savigny, Audouin, Macleay, Kirby, Carus, Strauss-Durckheim, Newman, and others, every segment of the perfect insect is made up of distinct parts, not always separable from each other or developed to the same extent, but existing primarily in all. It is also believed that the head itself is formed of two or more segments, but the exact number which enter into its composition is yet a question. So uncertain are the opinions held upon this subject, that while Burmeister recognizes only two segments, Carus and Audouin believe there are three, Macleay and Newman four, and Strauss-Durckheim, even so many as seven. These different conclusions of the most able investigators appear to have arisen chiefly from too exclusive examinations of the head in perfect insects, without reference to the corresponding parts in larvæ. It is only by comparing the distinctly indicated parts of the head in the perfect insect with similar ones in the larva that we can hope to ascertain the exact number of segments of which it is composed. In the head of the perfect insect there ought to be found some traces of all the segments which exist in the larvæ of the same species, and in that of the more perfectly developed larvæ that undergo a true metamorphosis there ought in like manner to be found the rudiments of all the segments in the least perfectly developed. Now, the common larva of the Dipterous insect,

---

[135] Memoirs of the Peabody Academy of Science, Salem, Mass., 1872. Pl. III.

the maggot of the flesh fly, is one of the lowest forms we have yet examined, and we have already seen that its head appears to be formed of four and perhaps even of five segments. This is the greatest number yet noticed in the head of the larva of any species. If, therefore, we can trace the like number in the head of a perfect insect, we may fairly conclude that this is the normal number of segments throughout the class. The head of the great water-beetle, *Hydröus piceus*, is remarkably well-fitted for exemplifying the number of segments of which the head is originally composed, the remains of four of the segments being distinctly marked; and it also affords us a proof of the correctness of the opinions advanced by Savigny and others, that the organs of manducation are the proper articulated members of distinct segments, and are perfectly analogous to the proper organs of locomotion.

"We shall first describe the parts of which the head is composed, and then endeavor to explain the manner in which these parts have been developed from several segments to form the perfect cranium and its appendages. It has hitherto been customary with naturalists to designate the head the first segment of the body, and as every change in the nomenclature of a distinct part ought always to be avoided, unless positively required, through fear of creating confusion, we shall not deviate on the present occasion from the established mode; but when speaking of it as a whole shall consider it the first segment, while the aggregation of segments of which it is composed we shall designate individually *sub-segments*, distinguishing them numerically in the order in which they appear to exist in the earliest condition of the fœtal larva."

If we apply the law enunciated by Savigny, and which holds good as a rule throughout the Hexapod Insects, *i. e.*, that each segment of the body of insects bears but a single pair of jointed appendages, we find that as the head of insects is provided with four pairs of appendages, viz., the antennæ, mandibles, first maxillæ, and labium (or second maxillæ), there must be four corresponding segments.

While the subject becomes clearer when, with Newport, we examine an insect in the larva state, the fact that the head of insects is really composed of but four segments becomes readily demonstrated when we examine the embryo at an early stage of its existence. In our embryological studies on the Thysanurous insects (*Isotoma*), on Neuropterous insects (Diplax), on the beetles and the flea and Hymenoptera (*Nematus ventricosus*), our attention was specially directed to this point, and it appeared very plain and easily demonstrable that the head of winged insects of all orders consists of four segments (arthromeres) and no more.[136]

An inspection of the figures published by the different writers on the embryology of insects appears to confirm this view, and in our "Guide

---

[136] See Embryological Studies on Diplax, Perithemis, and the Thysanurous genus Isotoma, by A. S. Packard, jr.; Memoirs Peab. Acad. Sc., Salem, 1871, p. 21; also Second Memoir, 1872. This view was stated in the author's "Guide to the Study of Insects," second edition. Graber (Die Insekten, München, 1879, p. 430) also states that the head is composed of four segments.

to the Study of Insects" (p. 20) we have given a tabular view of the four segments of the head and the appendages they bear. This view is fully confirmed by our studies on the embryology of the locust. If the reader will turn to Plate XVIII, Fig. 2, he will see the order of succession of the antennæ and mouth-parts. It will be seen that the antennæ and mouth-parts are outgrowths budding out from the four primitive segments of the head; that the antennæ grow out (compare also Pl. XVIII, Fig. 4) from the under side of the procephalic lobes, and that these should therefore receive the name of antennal lobes. In like manner the mandibles and first and second maxillæ arise respectively from the three succeeding segments. The figures by Kowalevsky and Bobretsky and by other observers, as well as those of the earliest stages of Diplax, Pulex, and Attelabus which we have published, show that the cephalic segments are first indicated, and that subsequently the appendages bud out from the under side at a point situated on each side of the sternal or median line of the body. It appears that the appendages arise between the sternal and pleural portions of the segment.

There, however, remains a portion of the head in front of the procephalic or antennal lobes, which afterwards becomes the clypeus and labrum or upper lip. Do these parts belong to the antennal segment, or are they rudimentary portions of a segment situated in front of our first segment? This lobe or outgrowth is evidently a single unpaired lobe which grows out in front of the antennal lobes, and is seen to form the front or upper wall of the mouth. We regard it as the tergal portion of the antennal segment, and the procephalic lobes as probably forming the pleural portion of the segment. The procephalic lobes, then, bearing the antennæ below, and higher up on the sides the eyes and ocelli, become the epicranium of the larval and adult insect. It follows, therefore, that the head of larval and adult insects is made up mostly of the first or antennal segment, and that the epicranium is the pleural portion of this segment, and the clypeus, and its offshoot the labrum, is the dorsal or tergal portion of this segment.

The only other portion of the head of certain adult insects which remains to be accounted for is the so-called "occiput." This forms the base of the head of Corydalis, a Neuropterous insect, which, however, is more distinct in the larva. In most other insects the occiput is either obsolete or soldered to the hind part of the epicranium. We have traced the history of this piece (sclerite) in Diplax, a dragon fly, and have found that it represents the tergal portion of the fourth or labial segment. In our memoir on the development of this dragon fly, Pl. 2, Fig. 9 (compare also Fig. — in text), the head of the embryo is seen to be divided into two regions, the anterior, formed of the first three segments, and the posterior, formed of the fourth or labial segment. This postoral segment at first appears to be one of the thoracic segments, but is often added to the head. A. Brandt's figure of *Calopteryx virgo*, Pl. II, Fig. 19, represents an embryo of a stage similar to ours, where the postoral or

fourth (labial) segment is quite separate from the rest of the head. Fig. 11 (in text), copied from our Memoir, also shows in a saw fly larva (*Nematus ventricosus*) the relations of the labial or fourth segment to the rest of the head. The suture between the labial segment and the pre-oral part of the head disappears in adult life. From this sketch it would seem that the back part of the head, *i. e.*, of the epicranium, may be made up in part of the tergite or pleurites of the mandibular segment, since the mandibular muscles are inserted on the roof of the head behind the eyes. It is this segment which in Corydalis evidently forms the occiput, and of which in most other insects there is no trace in larval or adult life.

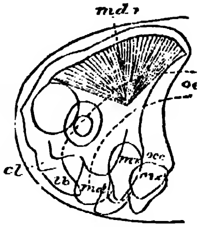


Fig. 11.—Head of Nematus, showing the labial segment, occ, forming the occiput: *cl*, clypeus; *lb*, labrum; *md*, mandible; *mdm*, muscle of same; *mx*, maxilla; *mx'*, maxilla (labium); *oes*, oesophagus.

It appears, then, that the epicranium, or that piece (sclerite) bearing the eyes, ocelli, and antennæ, and in front the clypeus and labrum, is formed from the original procephalic lobes, and represents the first or antennal segment, and is pleural, the clypeus and labrum being the tergal portion of the segment; while the remainder of the original or primitive segments are obsolete, except in those insects which retain traces of an occiput or fourth cephalic tergite. All of the gular region of the head probably represents the base of the primitive second maxillæ.

CHAPTER XI.

THE SYSTEMATIC POSITION OF THE ORTHOPTERA IN RELATION TO OTHER ORDERS OF INSECTS.

It may not be out of place, considering the amount of space given in the reports of the Commission to matters of a practical nature, and also taking into account the fact that these reports are widely sent to entomologists, as well as to farmers and planters, to give the scientific reader a brief sketch or abstract of the results of an examination of the external anatomy of the Orthoptera in general, of which the locust is a type. This we have attempted to do, but in undertaking this task we have been led perforce to examine those insects allied to the Orthoptera, *i. e.*, the Pseudoneuroptera and Neuroptera. This has led us to review the characteristics of the four lowest orders of winged insects. The results of this review we here present for the consideration of zoologists. It is believed that so detailed a survey of the external anatomy, especially of the thorax, of so many forms has not been made before, although much more thorough and exhaustive studies on a few insects have been made by Audouin, MacLeay, Newport, Strauss-Durckheim, Hammond, and others. The results have led us to quite different conclusions respecting the classification of the Neuroptera and Orthoptera, as originally limited by Linnaeus, from those which we have heretofore held. Our work is based on the researches of Audouin, MacLeay, and Newport, and the terms here used will be found explained in their original works, as well as in the author's "Guide to the Study of Insects." The reader is also referred to our account of the external anatomy of the locust in the Second Report of this Commission.

Any one who has examined a cockroach and a white ant, and seen how closely they resemble each other, must have felt that so far from representing two distinct orders, they appear rather to be types of two allied families of the same order. Again, while the larval cockroach or larval Forficula closely resemble the Thysanurous Lepisma, on the other hand a larval Perla also nearly approximates to a Lepisma. The explanation of these facts is to be sought in the probable genealogical history of the Orthoptera, which, with the Pseudoneuroptera and Dermatoptera, are evidently descendants from an ancestral form like Lepisma, their larvæ closely resembling this Thysanuran. We have therefore indicated in this chapter the probable lines of descent from the primitive hypothetical Thysanuran.

In making these studies we have, in order to be unbiased, disregarded the works of others, and gone over the field anew, as if nothing

had been done upon this subject. We have examined the fundamenta characters of the head, thorax, and abdomen, points neglected by most systematic writers, not spending much time on the peripheral, *i. e.*, the superficial adaptive characters of the mouth-parts, wings, and legs, which have been elaborated by systematic entomologists; believing that by this method perhaps more thorough and better grounded views might result. The outcome has been to lead us to separate the Neuroptera, as defined farther on, from the Pseudoneuroptera, and to regard these two groups, with the Orthoptera and Dermatoptera, as four orders of a category which may be regarded as a superorder, for which the name *Phyloptera* is proposed, as these four orders are probably closely allied to, if not in some cases identical with, the stem or ancestral groups from which probably all the higher orders—the Hemiptera, Coleoptera, Diptera, Lepidoptera, and Hymenoptera—have originated.

We will first briefly summarize the characters as we understand them of the *Phyloptera* as a whole; then the distinguishing marks of the four orders, then briefly discuss their probable genealogy, closing with a more extended though very condensed account of the essential peculiarities of structure of the families, as represented by one or more of the typical genera.

Superorder PHYLOPTERA.[137]

The mouth-parts are free, adapted invariably for biting; the mandibles being toothed and adapted for chewing; the first maxillæ separate, with three divisions, the outer bearing usually five-jointed palpi; the second maxillæ united to form a labium, divided into a submentum, mentum, and ligula, the latter varying much, being either cleft (Pseudoneuroptera) or entire (Neuroptera), and bearing usually a three-jointed palpus. This is the primitive, elementary condition of the mouth-parts, and such as obtains in Coleopterous larvæ. The head is notable from the great development of the epicranium. The clypeus is often divided into two portions, a posterior (post-clypeus) and anterior (ante-clypeus); in the other and higher orders the clypeus is entire.

The prothorax is usually very large and square, but in a few families, as the Phryganeidæ, Panorpidæ, Psocidæ, Libellulidæ, and Ephemeridæ, it is small and collar-like. There is a marked equality in size and form of the meso- and metathorax; in most Orthoptera and some Pseudoneuroptera and Neuroptera the metathorax is often even larger than the mesothorax; in this respect the *Phyloptera* differ from any of the higher Hexapoda. In both of the two hinder segments of the thorax the four tergal sclerites, viz: the præscutum, scutum, scutellum, and postscutellum, are each well developed, and more equably so than in the higher orders. The scutum is deeply excavated in front to receive the often large subtriangular or cordate præscutum; and in some genera

[137] From φῦλον, gens, nation; πτερόν, wing.

the scutum is, so to speak, cleft in two by the meeting of the præscutum and scutellum in the median line. The flanks of the thorax, or pleurites, are often very large, and the episternum and epimerum are broad, oblong, or squarish, and these sclerites are sometimes subdivided into an upper and lower division (supra- and infra- epimerum or episternum). The sternum is often large, flat, and broad; it is sometimes divided into a sternum and præsternum.

The wings are usually net-veined, often with numerous longitudinal veins, the branches of the subcostal, median, and submedian veins being either very long and parallel with the longitudinal axis of the wing, or numerous and small (especially in the hind wings of Orthoptera).

The hind wings are often (Orthoptera and Odonata) broader and larger than the anterior pair, the metathorax in such cases being a little larger than the mesothorax.

The abdomen has in this group, including representatives of the Neuroptera, Orthoptera, Dermatoptera and Pseudoneuroptera, besides a tenth, nearly complete segment, the rudiments of an eleventh uromere,[138] represented by a tergite forming the supra-anal triangular plate. Well developed jointed cercopoda occur in the Orthoptera and Pseudoneuroptera, while the forceps of Forficula (Dermatoptera) are undoubtedly modified cercopoda. An ovipositor occurs in the Neuroptera (Panorpidæ) and Orthoptera.

The metamorphosis is incomplete in all the orders of *Phyloptera* except the more recent and higher order, *i. e.*, the Neuroptera (in Erichson's sense), in which the transformations are complete, the pupa being quiescent and wholly unlike the larva.

The relative standing of the four orders of *Phyloptera* is shown in the table or genealogical tree of the winged insects on page 295.

The sequence of the orders, such as we are compelled to adopt in writing or speaking of them, is difficult to decide upon. Beginning with what on the whole may be regarded as the lowest order, we might first take up the Dermatoptera, which are in most respects the most generalized forms, and stand nearest to the Thysanura (Japyx).

---

[138] NOMENCLATURE OF EXTERNAL PARTS OF ARTHROPODA.—The following terms have been devised for convenience in anatomical and systematic work on the Arthropoda, and are submitted for the judgment of naturalists. We have adopted most of them in a monograph of N. A. Phyllopoda, published in Hayden's Twelfth Annual Report U. S. Geol. Surv. Terr., 1883.

The term *arthromere*, originally employed in the author's "Guide to the Study of Insects," in 1869, is now restricted to the body-segments of Arthropods, the term zonite or somite being used for the body-segments of worms, etc., as well as Arthropods. The "head," "thorax" and "abdomen" may be termed respectively *cephalosome*, *bænosome* (Gr. *baino*, to walk, locomotion), and *urosome*. The head-segments are termed *cephalomeres*, the thoracic segments *bænomeres*, and the abdominal *uromeres*. For the antennæ the term *æsthopoda*, and for the mandibles and maxillæ the previously used term *gnathopoda* is adopted.

The thoracic legs are termed *bænopoda*, and Westwood's term *uropoda*, applied by him to the terminal pairs of feet of the Tetradecapoda, is extended to all the abdominal feet of Arthropods. The basal abdominal feet of male Decapoda, modified as accessory reproductive organs, are termed, for convenience in descriptive carcinology, *gonopoda*, and the jointed anal cerci of certain insects and of Apus are termed *cercopoda* (κέρκος, tail; πούς, ποδός, foot). The elements of the ovipositor or sting are three pairs of blade-like appendages which are homologues of the legs; they may therefore be designated as *oöpoda*, as they are chiefly concerned in egg-laying.

The following is the succession of orders, placing the lowest uppermost:

Dermatoptera Burm.
Orthoptera Linn.
Pseudoneuroptera Erichson.
Neuroptera Linn., restricted by Erichson.

Before discussing the relative standing of these orders, we will briefly indicate the more salient and generally applicable differential characters, especially what we regard as the more fundamental ones, but slightly touching upon the mouth-parts and wings, these being peripheral and more adaptive characters and liable to greatest variation, and being of less value in characterizing the orders of *Phyloptera.*

ORDER 1. DERMATOPTERA.

Forficula presents so many features separating it from the Orthoptera, and is so composite a form, that it should be regarded as the type of a distinct order, in which it was originally placed by Leach, Kirby, Burmeister, and Westwood. Its composite nature is seen both in the elytra and the hind wings, which anticipate the Coleopterous type of wings. On the other hand the larva resembles Japyx, the Thysanuran, with its anal forceps, and in most respects Forficula is the lowest, most decided stem-form of the Phyloptera.

The Dermatoptera are characterized by the flatness of the body, and the large terminal forceps. The head is flat, horizontal in position, while the presence of the V-shaped epicranial suture is a sign of inferiority, as it is characteristic of Thysanura and Platypteran larvæ as well as Coleopterous larvæ. The remarkable thoracic structure, which is described farther on, as well as the curious overlapping of the abdominal tergites, forbid our uniting the Dermatoptera with the Orthoptera. The small, short elytra, and the very large, rounded, longitudinally and once-cross-folded hind wings, which remind us rather of the Coleoptera than Orthoptera, are also important diagnostic features. Finally, the metamorphosis of the Dermatoptera is even less complete than that of the Orthoptera.

The ligula (Pl. XXIII, Fig. 6) is bifid, being divided into a pair of two-jointed paraglossæ. The labium is thus similar to that of the Orthoptera, though scarcely more like them than like Termes.

ORDER 2. ORTHOPTERA.

The head is more or less vertical in position; the front is very large, broad, and long, the epicranial region very large and often hypertrophied. The clypeus is large and subdivided as in Pseudoneuroptera. In the Orthoptera, as a rule, the deeply-cleft ligula is indistinctly four-lobed, the outer pair of paraglossæ very well developed, while the inner pair is minute or undeveloped, as in the Acrydii, especially Caloptenus;

but in the Locustariæ the ligula is four-lobed, and in the Gryllidæ decidedly so. In the Mantidæ and Blattariæ the ligula is plainly four-lobed, nearly as much so as in the Termitidæ. In the Phasmidæ the ligula is intermediate in form between the Mantidæ and Locustariæ.

The prothorax is usually remarkably large, particularly the notum. The meso- and metanotum exactly repeat each other, and the metanotum is usually (Acrydii and Locustariæ) longer and larger than the mesonotum, the hind wings being almost uniformly much larger than the anterior pair. The pleurites are very large and square as well as high, the episterna and epimera being large and oblong and equally developed. The sternites are very large and broad. The coxæ are sometimes (Blatta) very large; the hind legs in the Acrydii are much larger than the anterior pairs. The fore wings are narrower than the hinder pair, and show a slight tendency to become subelytriform; on the other hand the hind wings are very large and broad, distinctly net-veined, with numerous longitudinal veins, and they fold up longitudinally.

The abdomen has eleven uromeres, the eleventh forming a triangular tergite. The cercopoda are often (Blatta, Mantis, &c.) multi-articulate and well developed, while the ovipositor is often large and perfect. The metamorphosis is more incomplete than in the Pseudoneuroptera.

With the exclusion of the Forficulariæ, the Orthoptera, as here restricted, are a tolerably well circumscribed group; and though there are great structural differences between the families, yet the connection or sequence of the families from the Blattariæ through the Phasmidæ and Mantidæ and Acrydii to the Locustariæ, and, finally, the highest family, the Gryllidæ, is one which can be distinctly perceived. There is no occasion for a subdivision of the order into groups higher than families, as the Blattariæ are but a family removed from the Mantidæ.

Order 3. PSEUDONEUROPTERA Erichson.

It is difficult, if not impossible, to satisfactorily characterize by a sharp-cut definition this very elastic order. As regards the thorax, there is no uniformity in the structure that we have been able to discover, nor is there in the structure of the wings, nor more than a general resemblance in the mouth-parts.

The definition of the Pseudoneuroptera in Hagen's Synopsis of the Neuroptera of North America, as given in the analytical table, which is stated in a foot-note to have been prepared at the request of the Smithsonian Institution by Baron Osten Sacken, gives no fundamental characters based on a study of the trunk. Those mentioned are what we have called peripheral characters, *i. e.*, those drawn from the mouth-parts, wings, and appendages. So far as we know, no satisfactory definition of the Pseudoneuroptera has ever been given. In Hagen's Synopsis, among the other superficial characters given, are these: "Lower lip mostly cleft"; "antennæ either subulate and thin, the tarsi three- to five-articulate; or setiform, or filiform, in which case the tarsi are two- to four-articulate."

These characters, though superficial, are the most important yet presented, perhaps (disregarding the metamorphosis), for separating the Pseudoneuroptera from the genuine Neuroptera. But the cleft labium is also to be found in Orthoptera; and among the Orthoptera, which usually have five-jointed tarsi, the Mantidæ have four tarsal joints. The Perlidæ, Odonata, and Ephemerina have been, by Gerstäcker (Peters and Carus' Zoologie), associated with the Orthoptera under the name *Orthoptera amphibiotica*, but such an alliance does not seem to us to be entirely a natural or convenient one; it is simply transferring a mass of heterogeneous forms to what, as now limited, is a natural and well circumscribed category, and yet we confess that it is difficult to give diagnostic adult characters separating the Pseudoneuroptera from the Orthoptera, though the general facies of the Orthoptera is quite unlike that of the the Pseudoneuroptera.

In the Pseudoneuroptera, beginning with the more generalized forms, the Perlidæ and Termitidæ, the labium (second maxillæ) is deeply cleft, the cleft not, however, in these or any other insects, extending to the mentum, or even clear through the palpiger. Each lobe is also cleft, so that the ligula is really four-lobed; the outer lobes are called by Gerstäcker[139] the "lamina externa," and the inner the "lamina interna." These finger-shaped, non-articulated, fleshy lobes appear to be homologous with, or at least suggest the outer pair of, paraglossæ of the Coleoptera and Hymenoptera. In the Perlidæ (Pl. XL, fig. 6) the four lobes of the ligula are well developed, and the lobes of the inner pair are broader than the outer. In the Termitidæ (Pl. XLI, figs. 2, 3) the lobes are well developed, but the inner pair of lobes is either one-half or not quite so wide as the outer paraglossæ; the palpiger is cleft. In the Embidæ, according to Savigny's figures, the ligula is four-lobed, but the inner pair is narrow and rudimentary.

In the Odonata, according to Gerstäcker's excellent drawings, the ligula varies much. In Gomphus it is entire; in some of the higher Libellulinæ only two-lobed; but in Æschna it is four-lobed, the outer lobe slender, but separate from the palpus. In Calopteryx the ligula is widely cleft, the two inner lobes are wide apart, while the outer pair is consolidated with the labial palpi. Owing to the specialized nature of the labial palpi, the mouth-parts of the Odonata are sufficiently *sui generis* and distinctive to prevent their being placed among the Orthoptera, even if the thorax were not so dissimilar. In the aborted labium and other mouth-parts of the Ephemerina we also have strongly-marked characteristics forbidding their being placed in the Orthoptera; were it not for the strong resemblance of the Termitidæ to the Orthoptera (Blattariæ,) probably no one would have thought of carrying the Pseudoneuroptera over into the Orthoptera.

The relative proportion of the head and sclerites varies greatly; no

[139] Zur Morphologie der Orthoptera amphibiotica. Aus der Festschrift zur Gesellsch. Naturforsch. Freunde, 1873.

general rule can be laid down as to the relative proportions of the epicranium and of the clypeus, or of the gular region.

On this account I had at one time decided to split the group into two, and to restrict Erichson's *Pseudoneuroptera* to the Platyptera,[140] and to adopt Latreille's term *Subulicornia* for the Odonata and Ephemerina (*Subulicornes* of Latreille). It may, however, be best, for the sake of clearness, to retain Erichson's order *Pseudoneuroptera* as he indicated it, and to dismember it into what may be regarded, provisionally at least, as three suborders:

1. *Platyptera* (Termitidæ, Embidæ, Psocidæ, and Perlidæ:=Corrodentia and Orthoptera amphibiotica in part).
2. *Odonata* (Libellulidæ).
3. *Ephemerina* (Ephemeridæ).

It is comparatively easy to give well grounded differential characters for these three suborders. They are so distinct that they may perhaps hereafter be regarded as entitled to the rank of orders, or the *Pseudoneuroptera* may be dismembered into the Pseudoneuroptera and Subulicornia (Odonata and Ephemerina).

1. *Platyptera.*—The body is flattened; the head horizontal. The pronotum is large, broad, and square. The meso- and metanotum are remarkable on account of the imperfect differentiation of the scutum and scutellum; the latter is indefinite in outline, but very large. The flanks (pleurites) are, when long, oblique, or are short. The sternites are usually very large and broad. There are often eleven uromeres.

2. *Odonata.*—While the Odonata and Ephemerina are somewhat alike as regards the form and venation of the fore wings, in their mouth-parts and thorax they are entirely unlike. The Odonata are remarkable for the great dorsal (tergal) development of the mesepisterna and the enormous development of the meso- and metapleurites in general, while the notum of the meso- and metathorax, though of the same type as the Orthoptera, is minute in size. The prothorax is very small, both dorsally and on the sides, forming a collar.

The wings are as markedly net-veined as in the Orthoptera, though the hinder pair are not folded longitudinally as in that order. The Odonata literally live on the wing, and thus the shape of the sclerites of the notum of the wing-bearing segments approaches that of the Orthoptera, although the prothorax is remarkably small compared with that of the Orthoptera, and forbids their union with this order, as was done by Gerstäcker and other German entomologists. The head of the Odonata is remarkable for the enormous size of the eyes and the consequent great reduction in size of the epicranium, as compared with the large epicranium of the Orthoptera. The mouth-parts are like those of the Orthoptera, except that the second maxillæ form a re-

[140] This name πλατύς, flat, πτερόν, wing, in allusion to the wings which in the majority (the Psocidæ folding their wings rather roof-like) fold their wings flat on the back. The Isoptera of Brullé comprise the Termitidæ alone.

markable, mask-like labium. The abdomen is very long, slender and cylindrical; there are eleven uromeres, the eleventh being well represented, while the cercopoda are not jointed, but in the form of claspers.

3. *Ephemerina.*—In the small epicranium, and the large male eyes, the Ephemerina resemble the Odonata, though the rudimentary mouth-parts are in plan entirely unlike them. So, also, the prothorax is small and annular, but the subspherical, concentrated thorax is remarkable for the large mesothorax and the small metathorax. Hence the hind wings are small and sometimes obsolete. The long, slender abdomen has ten uromeres, and bears, besides the two long, filamental multiarticulate cercopoda, a third median one.

The larvæ of the lower Odonata and of the Ephemeridæ closely approach in form those of the Perlidæ, showing that the three suborders here mentioned probably had a common ancestry, which can be theoretically traced to a form not remote from Campodea. By reason of the general resemblance of the larval forms of these three suborders it would be inadvisable to separate the Odonata and Ephemerina from the Platyptera, although, when we consider the adult forms alone, there would appear to be some grounds for such a division.

Order 4. NEUROPTERA.

The head is horizontal and somewhat flattened, except in the Trichoptera and Panorpidæ, where it is subspherical and vertical. The body shows a tendency to be round or cylindrical, the thorax being more or less spherical, but there is great diversity in form from the Sialidæ to the Trichoptera. The mouth-parts are free and the mandibles well developed, except in the Trichoptera, where the mandibles are nearly obsolete in form, and functionless, thus suggesting or anticipating the Lepidoptera.

In the Neuroptera the ligula is entirely unlike any of the foregoing and lower groups. It is entire, forming a broad, flat, large, rounded lobe; it is largest in Myrmeleon, Ascalaphus, and Mantispa, but smaller in Corydalis, where it is also narrower, and indented on the front edge.

In Panorpa the ligula is minute, rudimentary (Pl. LIX, fig. 7). In the Trichoptera it is also minute and rudimentary (Pl. LIX, fig. 5).

The prothorax is usually (Planipennia) large, broad, and square, but is ring- or collar-like in the Trichoptera, being short and small, much as in Lepidoptera. Except in the Trichoptera, the meso- and metanotum are characterized by the large, cordate præscutum, and in the Hemerobina the metascutum is partially or (in Ascalaphus) wholly cleft, the præscutum and scutellum meeting on the median line of the thorax.

In the Hemerobina and Sialidæ the metathorax is as large, or nearly as large, as the mesothorax, and the hind wings are as large as the anterior pair. The wings are not net-veined, the type of venation being entirely unlike that of the Orthoptera and Pseudoneuroptera. The

costal space is wide and well marked, and the transverse veinlets are few and far apart, compared with the two orders just mentioned.

The abdomen is cylindrical, and there are 9–10 uromeres. The ovipositor is only developed in Raphidia, while the cercopoda are not developed. The metamorphosis is complete, as in the Lepidoptera, etc., the pupa being entirely unlike the larva, and quiescent, often protected by a cocoon or case. The order may be divided into two suborders:

1. *Planipennia* (Sialidæ, Hemerobiidæ, Panorpidæ).
2. *Trichoptera* (Phryganeidæ).

The following tabular view and diagram will in a degree express our views as to the classification of the orders of the Hexapodous or winged insects, with especial reference to the Pseudoneuroptera, the order perhaps the most difficult to bring in relation with the other Phyloptera. The diagram will also serve to express our conceptions of the genealogy of the Hexapodous orders.

View of the grand divisions of winged insects (Hexapoda).

Superorders.	Orders.	Suborders.
Euglossata[141]	Hymenoptera	
	Lepidoptera	
	Diptera	Diptera (genuina). Aphaniptera. Pupipara.
Elytrophora[142]	Coleoptera	Coleoptera (genuina). Strepsiptera.
Eurhynchota[143]	Hemiptera	Homoptera. Heteroptera. Physapoda. Mallophaga.
	Neuroptera	Trichoptera. Planipennia.
Phyloptera	Pseudoneuroptera	Odonata. Ephemerina. Platyptera.
	Orthoptera	
	Dermatoptera	
Synaptera[144]	Thysanura	Cinura. Symphyla. Collembola.

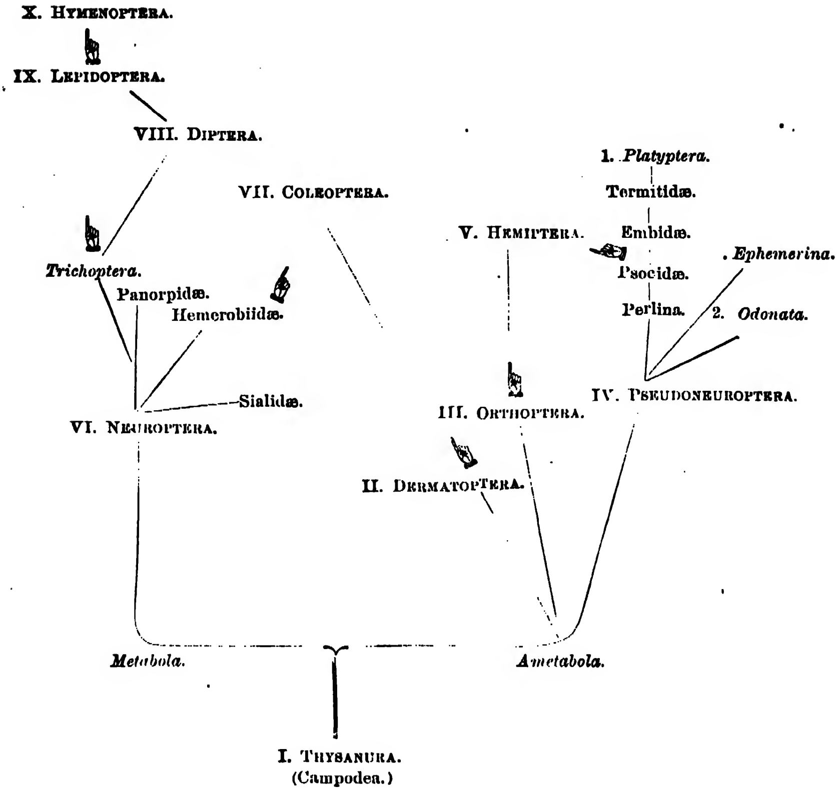
141 We propose the name *Euglossata* for the highest insects, comprising those orders which, besides having the mouth parts (either the first or second maxillæ, or both) modified so as to sip, suck or lap up liquid food, also have the body cylindrical, and the thorax more or less spherical and concentrated.

142 This term is proposed for the Coleoptera, which are nearly equivalent to the other superorders, being a remarkably circumscribed group.

143 This term is proposed for the Hemiptera, in all of which, except the Mallophaga and Physapoda (Thrips), the mouth parts are united to form a sucking beak.

144 This term is proposed for the Thysanuran apterous Hexapods which are perhaps nearly the morphological equivalents of either of the four other superorders.

GENEALOGY OF THE INSECTS (HEXAPODA).



GENEALOGY OF THE HEXAPODA.

I. *Thysanura.*—This order once comprised some lost types nearly resembling Lepisma, Campodea, and Japyx, and more especially Scolopendrella, the probable stem-form of the Hexapoda. In other words, from a hypothetical form resembling Campodea or Scolopendrella, it is not difficult to suppose that all or at least the majority of Hexapoda took their origin. It is possible that by a few intermediate steps now lost, Forficula may have descended from the Thysanuran Japyx; this is suggested by the form of the body, the head with its V-shaped suture, and the abdomen with its forceps, so like that of Japyx. The genus Lepisma is a rather more specialized form than Campodea, and Machilis is still more so, as proved by its mouth parts and the presence of compound eyes. Scolopendrella, with its abdominal true legs, comes nearer to our hypothetical form than even Campodea. The group of *Poduridæ* (Collembola) is most probably a series of degradational forms, originally sprung from a higher, more generalized, Campodea-like ancestor.

II. *Dermatoptera.*—This order, represented by but one family, differs, as already stated, from the Orthoptera, with which it is usually classi-

fied, much more than the Termitidæ. It stands alone, and, as observed, its larvæ closely resemble the Thysanuran Japyx.

III. *Orthoptera.*—After the elimination of the Forficulidæ from the Orthoptera, we have a natural and easily circumscribed group. Beginning with decidedly the most generalized and at the same time lowest family, the Blattariæ, followed by the Mantidæ, which have a number of characters which recall the Blattariæ, we pass up through the Phasmidæ to the typical family, the Acrydii; then succeed the Locustariæ, and finally the Gryllidæ, which on the whole are farthest removed from the stem-forms of the order, the Cockroaches. The close resemblance of a larval Cockroach to Lepisma indicates the direct descent of the Orthoptera from the Cinurous Thysanura.

IV. *Pseudoneuroptera.*—This is the most heterogeneous order or assemblage of insects. While it is comparatively easy to circumscribe the Neuroptera (taken in Erichson's sense). and the Orthoptera as here restricted, the group Pseudoneuroptera is remarkably heterogeneous and elastic. We have failed to satisfactorily diagnose the order as a whole. The Termitidæ connect the Orthoptera and Pseudoneuroptera so closely that, excepting in the wings and other peripheral characters, they seem but a family removed from the Blattariæ. For example, the Termitidæ resemble the Blattariæ in the form of the epicranium, in the clypeus, which is but partially differentiated at the base from the epicranium, in the form of the labrum, and the small eyes as well as the mouth-parts.

In the thorax the Termitidæ approach the Blattariæ in the undifferentiated scuta of the meso- and metathorax; while the pleurites are also very oblique and the femora are flattened and ovate in form, as in Blatta. In the abdomen, as regards the form of the tergites, as well as the urites and pleurites, besides the form of the end of the abdomen and of the cercopoda, the Termitidæ closely approach the Blattariæ. The degree of metamorphosis is also the same.

On the other hand, the close relationship of the Termitidæ to the Embidæ, as well as to the Psocidæ and also the Perlidæ, and the close resemblance of the Perlid larvæ to those of Odonata and Ephemerina, forbid our removing the Platyptera from the Pseudoneuroptera.

We conclude, then, that the Ephemerina, Odonata, Platyptera, as well as Orthoptera and Dermatoptera have had a common origin from some Thysanuran stock. It is possible that these five groups are nearly equivalent and should take the rank of orders, but the classification we have given in the tabular view on p. 294 may better express their relations.

The Odonata and Ephemerina are, as regards the wings and metamorphosis, a good deal alike. The Ephemerina, while having a highly concentrated thorax, are, as regards the mouth-parts and hind wings, degradational forms, the result of probable degeneration from a primitive, lost form. From what group the Ephemerina may have originated it seems to us impossible to conjecture.

V. *Hemiptera.*—The only clew to the origin of this well circumscribed order is the fact that in the Physapoda (Thrips) and the Mallophaga the mandibles are free and adapted for biting. This would indicate that the entire group was derived from ancestors allied possibly to the Phyloptera. The Mallophaga are by different authors referred to the Orthoptera and Neuroptera, but the development of the bird-lice as worked out by Melnikow fully proves that in the form of the egg, the mode of development, and general form of the embryo, the Parasita and Mallophaga travel along the same developmental path until just before hatching, when in Mallophaga the jaws remain free, while in the Parasita they become farther modified and form a sucking beak.

There is a possibility that the Hemiptera may have descended from insects remotely allied to the Pseudoneuroptera; perhaps forms resembling the Psocidæ; at least this family, the wingless forms of which superficially resemble the Mallophaga, gives hints which may throw light on the origin of the Hemiptera. They are evidently the offshoot of a stock which had an incomplete metamorphosis, or they may have descended directly from a modified Campodea-like ancestral form.

VI. *Neuroptera.*—The members of this order are, excepting perhaps the Hemiptera, the most modern and least composite or synthetic forms that we have yet met with in our ascent up the insect series from the Thysanura. Moreover, in them for the first time do we meet with worm-like, cylindrical-bodied larvæ, or what we have called eruciform larvæ.[145] These larvæ are secondary forms, derived, as Fritz Müller has in a general way suggested, from those larvæ which have an incomplete metamorphosis. By what line of descent, however, the lowest group of Neuroptera, viz., the Sialidæ, arose, it would be difficult to say. The earliest winged insects were probably terrestrial; the aquatic larval forms of the Sialidæ are evidently derivations from Campodea-like terrestrial larvæ. But how the perfect metamorphosis with the quiescent pupa of the Neuroptera was brought about, is indeed a problem. It is evident, however, that the eruciform larva is a derivation from a Thysanuriform[146] type, first stated by Fritz Müller.

It seems to us that a consideration of the diverse larval forms which occur in the present order, throws some light on the origin of a complete metamorphosis in insects in general. In the Sialidæ, as the larva of Corydalus, or Semblis, we have a Campodea-form provided with gills, and with the mouth-parts adapted for seizing and biting its prey. The terrestrial larvæ of the Hemerobiidæ are evidently modifications of the Sialid larval form; the differences of structure in them, such as the long,

[145] See "Our Common Insects," p. 175, 1873. Also the American Naturalist, vol. V, Sept. 1871.

[146] We have in the writings just quoted called the second class of larvæ Leptiform, but the term Thysanuriform, or Brauer's expression Campodea-form, is preferable. The Campodea or primitive Hexapodous form is evidently a derivative form, which points back to a common six-footed ancestor of all Tracheata, to which the term *Leptiform* may be applied.

slender mandibles and maxillæ and the short abdomen, being the result of their carnivorous habits, and their being obliged to climb up the stems of plants or to walk over the leaves after smaller insects. Under such circumstances the body would become shorter and more concentrated, and the legs well developed. In the Trichoptera, whose larvæ live in cylindrical cases, the body is seen to be essentially Campodea-like; the head is fundamentally like that of Corydalis; the differences are adaptive.

But when we regard the larva of the Panorpidæ, we are dealing with a new type; it is caterpillar-like, eruciform; its body is slender and cylindrical, the head small, and feet short and small. Notice also its habits. The larva of *Panorpa communis* of Europe, as described by Brauer,[147] is remarkably caterpillar-like or eruciform. The head is small, well rounded, and the antennæ and mouth-parts are small and rudimentary, compared with those of other Neuroptera, not excepting the Trichoptera. Moreover, they are constructed on nearly the same type as those of caterpillars; for example, the mandibles are short, toothed, of the same form as in Lepidopterous larvæ; the maxillæ are short, and whether more than two-lobed Brauer does not state, though his figure indicates apparently a rudimentary third lobe; the palpi are four-jointed, while the labium is small with small three-jointed palpi.

The form of the body is thick and stout, like that of a Bombycid (Arctian) larva. The short, four-jointed thoracic feet are in length and thickness like those of caterpillars. But the most striking resemblance to caterpillars and saw-fly larvæ is seen in the eight pairs of abdominal feet, which Brauer describes as conical or pin-shaped (kegelförmig), while on the last (ninth or tenth?) segment are four finger-shaped, equal processes. Not only the form of the body, but also the arrangement and shape of the button-like setiferous warts on the body are strikingly like those of some Arctian caterpillars. The pupa has free limbs and wings as in other Neuroptera. The larva of Panorpa bores an inch deep into moss-covered, not wet soil.

The larvæ of Bittacus (*B. italicus* and *hagenii*), as also described and figured by Brauer,[148] have a rounded head, with small mouth-parts; the mandibles are, however, rather long, compared with those of Panorpa; while the maxillæ have apparently two inner short lobes, and a four-jointed, short maxillary palpus; the labium is rudimentary, with a pair of short, minute, two-jointed palpi. The body is not so thick as in Panorpa; it is cylindrical and adorned with long, scattered, dorsal spines, which bear one or two branches near the base, while there is a lateral row of slender filaments, and a row of ventral verticillate hairs. It thus bears a resemblance to the larvæ of some butterflies, as *Vanessa antiopa*, and especially the young Polyommatus (*Heodes hypophleas*) or the Bombycid larvæ of *Anisota stigma* or Platysamia, as well as Selandria

[147] Sitzungsberichte math.-naturw. Classe k. Akad. Wiss., Wien, 1851. Tafel 1.
[148] Verhandlungen k. k. zool.-bot. Gesellschaft in Wien, 1871.

larvæ. Brauer's figures show a pair of abdominal, two-jointed feet to each of the nine abdominal segments, while just as in Lepidopterous larvæ and in that of Panorpa there is a pair of prothoracic spiracles, none on the mesothoracic or metathoracic segments, and there are nine pairs of abdominal spiracles according to Brauer's figure, or one more pair than in Lepidopterous larvæ.

The fact that there are in the larval Panorpidæ collectively a pair of feet to each abdominal segment (the terminal segment in Panorpa bearing what are evidently homologues of the anal proplegs of caterpillars) is of much significance when we bear in mind that while no caterpillars are known to have more than five pairs of abdominal or proplegs, some of the segments bearing none, yet the embryos, as shown by Kowalevsky, have temporary embryonic indications of legs, a pair to each segment (uromere); it is a significant fact that the eruciform larvæ of the Panorpidæ actually have two-jointed legs to each abdominal segment, the penultimate segment in Bittacus bearing such legs, and the terminal segment bearing leg-like processes in Panorpa. The origin of the Lepidoptera from the same stem-form as the Panorpidæ thus seems a reasonable hypothesis.

In the metamorphosis of Mantispa, as Brauer has shown, there is a hypermetamorphosis, *i. e.*, two larval stages. The first stage is Campodea-form; but the second is sub-eruciform. The transformations of Mantispa appear to give us the key to the mode in which a metamorphosis was brought about. The larva, born a Campodea-like form, active, with large, long, four-jointed feet, living a sedentary life in the egg-sac of a spider, before the first molt loses the use of its feet, while the antennæ are partly aborted. The fully grown larva is round-bodied, with small, caterpillar-like feet and a small, round head. Its external appendages retrograding and retarded, acceleration of growth goes on within, and thus the pupal form is perfected while the larva is full-fed and quiescent; hence as a result the pupal stage became a quiescent one, and by inheritance it gradually became a permanent habit characteristic of Neuroptera, all of which have a complete metamorphosis, and hence inherited by all the orders of metabolic insects which probably originated from Neuroptera-like forms, and the imago represents a highly accelerated stage.

When we consider the imagos or adult Neuroptera: the small, collar-like prothorax, the spherical, concentrated thorax as a whole, and the cylindrical abdomen, are features which give them a comparatively specialized and modern aspect. Without doubt the Neuropterous labium (Plate LIII) is a secondary product compared with that of the Orthoptera or the Platyptera, where it is deeply cleft (Plate XXVII.) It will be remembered that in the embryo of all insects the labium or second maxillæ originates like the first pair.

Origin of the Coleoptera.—Although the beetles are a remarkably homogeneous and well circumscribed order, there are certain larval forms and life-histories which point out with a tolerable degree of cer-

tainty the line of development of this extensive order from the Campodea type. There are two series of facts which seem to us to throw light on the subject.

First, the form of the free, active larvæ of the carnivorous groups of beetles. The larvæ of the Carabidæ, Dytiscidæ and Staphylinidæ appear to us to be on the whole more nearly allied to what was probably the primitive form of Coleopterous larva than those of any other families. This ancestral Coleopterous larva was probably directly related to the Campodea-form ancestor of the Hexapoda. The general form of the body, the homonomous segments, the free, biting, toothed mandibles, the well-developed one- or two-lobed maxillæ with their three-jointed palpi, and the well-developed second maxillæ (labium), also the four-jointed antennæ, and the presence of ocelli, while showing that the existing carnivorous larvæ are the most specialized and highly developed, also show that they have undergone the least modification from the primitive type of Coleopterous larva. In the scavenger larval forms, as the Silphidæ, Dermestidæ and allied families, the mouth-parts begin to be modified and less developed, and the form of the body undergoes a change, becoming thicker and with less developed feet.

In the Elateridæ and Scarabæidæ, which in general are phytophagous, we see a still more decided change; the body becoming cylindrical and the mouth-parts more aberrant.

In the wood-boring Buprestidæ and Cerambycidæ, and in the leaf-eating Chrysomelid larvæ, we witness a decided departure from the carnivorous type; the mouth-parts show a tendency to become more or less aborted, the legs are frequently wanting and the body more or less maggot-like. Finally, the tendency to a gradual degradation and atrophy of the head, mouth-parts and legs culminates in the grubs of the weevils (Curculionidæ and Scolytidæ), placing them at the foot of the Coleopterous series, and shows that they have undergone the greatest modification of form, and have become adapted to conditions the most unlike those which constituted the environment of the primitive Coleopterous larva.

The relative form of the maxillæ appears to be a good index as to the general development of the body in the different groups of Coleoptera, especially those standing above the wood-boring families. The facts may, for convenience, be arranged in the following form:

Cicindelidæ.—Maxilla with a maxillary lobe or *mala* proper ending in a 2-jointed appendage which is longer than the 3-jointed palpus. (Antennæ 4-jointed; 3 ocelli.)

Carabidæ.—Maxilla with the mala 2-jointed; maxillary palpus 4-jointed. (Antennæ 4-jointed, bifurcate; ocelli often present.)

Dytiscidæ (and Hydradephaga in general).—Maxilla with the mala absent; the palpi 4-jointed.

The maxilla in the aquatic forms of the Carabid type is only a modification of the Geodephagous maxilla; the terminal palpal joint being acute and raptorial.

Staphylinidæ.—Maxilla with a 1-jointed inner lobe (Xantholinus), or the mala broad and setose as in the succeeding families (Platystethus and especially Bledius); maxillary palpi 3- and 4 jointed.

The Staphylinid type of maxilla is simply a modification of the Carabid, with a tendency to degeneration in the lower genera (Bledius, etc). Many larvæ in this family are carnivorous.

Elateridæ.—Maxilla with a 2-jointed lobe or mala; the maxillary palpus 4-jointed. Antennæ 4-jointed, bifurcate as in Carabid larvæ; mandibles toothed. The maxillæ of Elater and Athous are free. While generally supposed to be vegetable-eaters (as Agriotes), those larvæ which live under the bark of trees in mines made by Longicorn and other borers have been shown by Ratzeburg, Dufour and Perris to be in part carnivorous, living on Dipterous and Longicorn larvæ, as well as on the excrementitious vegetable matter filling the burrows. Perris (*Insectes du Pin maritime*, p. 190) has pointed out the close resemblance of the mouth-parts of this family to those of the larval Carabidæ.

In the Scarabæidæ, Buprestidæ, and all the lower families of Coleoptera, the maxillæ are of a rather simpler type than in the foregoing families; the maxillary lobe, or mala, being simple and more or less fringed with stiff hairs. In the Scarabæidæ (Osmoderma), and in Pyrochroa, which is carnivorous, the mouth-parts are as complicated as in any; but in the Buprestidæ and Chrysomelidæ they are less developed, while they are most rudimentary in form and size in the wood-boring weevils and Scolytids; the antennæ and second maxillæ and legs also share in the degradation of structure consequent on the burrowing lignivorous habits of the larvæ.

But it is in the so-called hypermetamorphosis of the Meloidæ, that of the blister beetle (Epicauta) as well as Hornia having been fully described and illustrated by Professor Riley in the First Report of the United States Entomological Commission (p. 297–302, Pl. IV), that we have a clew to the probable origin of the different types of Coleopterous larvæ. The metamorphosis of the oil beetle (Meloë) originally discovered by Siebold and Newport and also Fabre, is described in different entomological manuals.[149] In brief, the larvæ of Meloë when hatched are very minute, active, six-legged, slender-bodied creatures, parasitic on wild bees; as the legs end in three claws the insects in this stage are called "triungulins." These larvæ attached to the bees are thus carried into the nests of the latter, where they feed on the bee-larvæ and bee-bread. On becoming fully fed, instead of transforming directly into the pupa state, they assume a second (coarctate) larval form, entirely unlike the first, the body being cylindrical and motionless, with long legs; they then attain a third larval stage, the head small and the body thick, cylindrical and footless; after this they assume a true pupa stage, and finally become beetles.

Professor Riley has traced the hypermetamorphosis of the blister

[149] See the writer's "Guide to the Study of Insects," pp. 477–479, figs. 447–451.

beetle (Epicauta), which passes through three larval stages before transforming to a pupa. He divides the life-history of this beetle into the following stages: (1) Triungulin; (2) second larva (*a*, Carabidoid; *b*, ultimate or Scarabæidoid stage); (3) pseudo-pupa, or coarctate larva; (4) third larva (closely resembling the Scarabæidoid stage of second); (5) true pupa; (6) beetle. (The reader should examine the figures in Pl. IV of the First Report; otherwise he cannot understand the following remarks.)

It appears, then, that the first larva, or triungulin, in form resembles the Campodea-like primitive larval form of Coleoptera; the Epicauta triungulin closely resembles a Carabid larva, the head, antennæ, and mouth-parts, as well as the legs and form of the body in general, being on the primitive, Carabid type (somewhat like Casnonia (?), Galerita and Harpalus); the second larva, *a*, Carabidoid stage, though quite different as regards the mouth-parts, and with a smaller head, thicker body and much shorter legs, still adheres to the higher Carabid form (Carabus and allies). During the Scarabæidoid stage the second larva rests nearly motionless in the egg of the locust, and is like the curved, clumsy larvæ of the cockchafer or June beetle and other Lamellicorn larvæ, which also have the similar habits of lying still in their burrows and feeding on the roots of grass, or, as in the case of Osmoderma, lying nearly motionless in their cells in rotten wood. This sort of life going on, the larval blister beetle after six or seven days assumes the ultimate stage of the second larva, and now, from apparent continued disuse, the mouth-parts and legs become more aborted than before, and the insect in this stage may be compared to some Longicorn larvæ, with a general resemblance in the curved, cylindrical body to the Ptinid and Chrysomelid, and it even approximates in general shape Curculionid larvæ. In the pseudo-pupa or coarctate larva this process of disuse and obsolescence of parts culminates in the immobile stage preceding (with the intervention of third larva) the pupal condition. We thus see that in the life-history of a single species of beetle, change in habits or environment, as well as in the food, induces change in the form of the body; and this series of changes in the Meloidæ typifies the successive steps in the degradation of form which characterize the series of Coleopterous larvæ from the Carabidæ down to the Curculionidæ and Scolytidæ. At first all larvæ were carnivorous and active in their habits, with large mandibles and well developed accessory jaws and legs; certain forms then becoming scavengers, their appendages became, from disuse, less developed; then others, becoming phytophagous, became in some cases still less developed, the jaws shorter and toothless, with corresponding modifications in the other mouth-parts, the antennæ and the legs, while the body became thick, fat and cylindrical; until in the wood-boring and seed- or nut-inhabiting weevils the antennæ and maxillæ became rudimentary, almost disappearing, while the legs utterly vanished. Change of habits and surroundings, with corresponding changes in the

form of the body and its appendages, both explain the metamorphosis of insects in general and also the differences between the larval forms of the different orders.

The following view will convey an idea of the larvæ of the Coleopterous families which in a general way correspond to the different larval stages of the Meloidæ; it being understood that the resemblances are suggestive and general, and not to be accepted in a too literal sense.

1. Primitive triungulin stage.	In Meloë more like Campodea than in Epicauta. Meloidæ. Stylopidæ.
2. Carabidoid stage.	Cicindelidæ. Carabidæ, Dytiscidæ, Hydrophilidæ. Silphidæ, Nitidulariæ, Dermestidæ, Coccinellidæ, etc. Elateridæ, Lampyridæ, Telephoridæ, Cleridæ, Pyrochroidæ.
3. Scarabæidoid stage.	Histeridæ. Scarabæidæ. Ptinidæ.
4. Coarctate stage, more or less cylindrical and apodous.	Cerambycidæ. Tenebrionidæ. Mordellidæ. Curculionidæ. Scolytidæ.

From the facts and considerations which have been presented, we are disposed to believe, subject, of course, to future correction, that the primitive Coleoptera were carnivorous forms, and that the scavenger and phytophagous forms have been derived from them, and are therefore secondary products, and as a whole of more recent origin.

The primitive form of beetle was probably a Staphylinus-like form, with a long, narrow body and rudimentary elytra, and carnivorous in habits. This has been suggested by Brauer,[150] though it occurred to us before meeting with his views.

Though the earliest beetle known is a Carboniferous weevil-like form, yet we imagine the Coleopterous type became established in Devonian or Silurian times, when there may have existed the prototypes of the earwigs and beetles; for the two types may have branched off from some Thysanuran form. On the other hand, the primitive Coleopterous larva may have sprung from some metabolous Neuropterous form. The larva of Gyrinus has a striking resemblance to that of Corydalus and other Sialidæ, so much so that a terrestrial Carabidous form most probably was of Neuropterous origin, as indicated in our diagram.

Origin of the Diptera, Lepidoptera, and Hymenoptera.—The Euglossata probably had a common origin in the first place from the metabolic

[150] So wird uns der Staphylinus als eine der ältesten Käferformen gelten, etc. Betrachtungen über die Verwandlung der Insekten im Sinne der Descendenz-Theorie, von F. Brauer, Verh. k. k. zool.-bot. Ges., Wien, 1869, p. 313.

Neuroptera. The Lepidoptera probably originated from the same group from which the Panorpidæ and Trichoptera branched off, and we agree with the opinion of H. Müller,[150] who maintains that the Lepidoptera and Trichoptera "proceed from a common stock," though we should suppose that the Panorpidæ in their larval stage represented forms like the ancestral caterpillar.

The adult structure and larval forms of the Diptera show that they originated from nearly the same stock as the moths. The most perfectly developed Dipterous larvæ are those of the Culicidæ and Tipulidæ; these were probably the primitive forms; the other Dipterous larvæ, notably the larval Muscidæ or maggots, are degradational forms, and the lower Diptera appear to have been degraded or degenerate forms.

The case is different with the Hymenoptera. The saw-fly larvæ represent apparently the primitive larval form; and from their resemblance to caterpillars and Panorpid larvæ, show that the Hymenoptera and Lepidoptera may have had a common origin. The footless larvæ of the parasitic Hymenoptera are correlated with their parasitic mode of life, and the similar forms of the larval wasps and bees show that from disuse their mouth-parts and legs became aborted, and the immobile larvæ became short and thick-bodied. Hence such larvæ should be regarded as secondary, adaptive larval types. The high degree of specialization of the bees' mouth-parts, their concentrated bodies and 4-segmented thorax, with other characters, show that they are the highest, most specialized and modern of all insects.

NOTE.—It should be borne in mind that the embryo bee has a pair of temporary abdominal appendages on each segment (uromere); so also has the Lepidopterous, Coleopterous, and Orthopterous embryo, which points back to a common, Scolopendrella-like type; this also possibly indicating a still earlier, worm-like, Peripatus-like ancestor for Myriopoda and Hexapoda at least, if not Arachnida. For previous discussions as to the origin of insects the reader is referred to the writings of Fritz Müller, Brauer, Lubbock, and the author.

Order II. DERMATOPTERA.

FORFICULIDÆ. Plates XXIII, XXIV.

THE HEAD.

Forficula tæniata Dohrn. (Pl. XXIII, figs. 1–3). The head is horizontal in position, broad and flat, squarish, the sides being parallel. There is a V-shaped epicranial suture, which is more distinct in the larvæ of this genus and in Labia. The epicranium is otherwise simple; no ocelli. The clypeus is simple, being no wider and not much larger than the labrum. The genal ridge prominent; a broad gular region. Behind the

---

[150] American Naturalist, v, July, 1871, 288. See also the same magazine, Nov., 1871, p. 707–718.

short, broad submentum (and in front of the prosternum) is a free sclerite, with a transverse, median impressed line. (This sclerite may be called the *postgula*, and it may correspond to the præsternal sclerite in Blatta, except that no pleural sclerite is attached to it as in Blatta.) The mentum is very large and flat, as long as broad.

THE THORAX.

Notum.

Pronotum. (Fig. 7.) Large, flat, square, a little longer than broad, and rounded behind.

Mesonotum. (Fig. 8.) Somewhat as in Termes, being almost entirely concealed by the pronotum, which rides over it. It is very short—indeed, remarkably so—no other insects approaching this group in this respect, while the metanotum is remarkably developed. Neither the meso- nor metanotum are so wide as the thorax, a broad margin of membrane bordering the sides.

The mesoscutum forms a very short, transversely sublinear sclerite, with the front edge full and curved, but linear (in a transverse sense) on the sides; behind, it receives the minute, diamond-shaped scutellum, which forms a posterior, spine-like projection, which rubs or plays upon the medially chitinous front edge of the metanotum. On each side of the scutellum is a transverse, long, lanceolate-oval, chitinous sclerite, which we are disposed to regard as the divided postscutellum. There is no praescutum, and in front of and behind the mesonotum the thorax is soft and membranous.

Metanotum. (Fig. 8.) There is no præscutum. The scutum is very large, nearly as broad as long, broad in front, narrowing behind, sinuous on the front edge, slightly rounded behind, the surface generally flattened, a little convex, with two parallel, slightly converging median ridges; behind these two ridges is the narrow, longitudinally somewhat oblong scutellum. It is not defined by suture, and I could not decide what it was until I had examined Labia, in which it is more distinctly separated from the scutum; it is thick, dark, with a spine-like projection in front.

The large, long and broad, more or less flat area between the scutum and first uromere we are disposed to regard as, without much doubt, an enormously developed postscutellum, especially as it is much shorter and more like the postscutellum of Labia. Its surface is broken up into areas; from behind the metascutellum two widely diverging ridges pass backward and outward to support the base of the wings.

Pleurum.

The pleurites are remarkable for being extended horizontally, and for the unusual form and relations of the epimera, in these respects suggesting the Coleoptera, and perhaps the Staphylinidæ. The legs

are inserted at the posterior end on the side of each segment (bænomere), as the coxæ are widely separated by the very large and broad sternites.

Propleurites. (Pl. XXIV, fig. 1.) These are well developed. The episternum is horizontal, flat, subtriangular, narrow, reduced to a point before reaching the coxa. A wedge-shaped, triangular sclerite is wedged in between it and the sternite (this may be regarded as the sub-episternum, though possibly the trochantine, as the coxa is apparently entire, and there is otherwise no trochantine to be found).

The epimerum forms the upper part of the pleurum, and is scale-like, oblong-oval; in front it is narrow, and ends at the anterior margin of the notum. The posterior or upper end of the epimerum is free, rounded, scale-like, as it covers the prothoracic stigma.

The coxa is cylindrical, shorter than broad. I can perceive no suture in it, and think the trochantine is obsolete.

Mesopleurites. (Fig. 2.) These sclerites repeat the form of the propleurites. The segment (bænomere) is not so long, and the sclerites are a little more horizontal. The epimerum is more regularly oblong-oval, with a deep crease or fold below the middle, which extends obliquely from near the coxa to the front edge of the epimerum.

The episternum is in this segment, as in the preceding one, divided into two pieces; the sur-episternum is very small and situated in the same plane as and on the side of the anterior end of the sternum. The triangular sub-episternum is more oblique than in the propleurum. The coxa is smaller than in the prothorax.

Metapleurites. (Fig. 3.) The structure of this region is very remarkable, as compared with that of other *Phyloptera.* The episternum is simple, not subdivided as in the pro- and mesopleurum, but represented by an acutely triangular sclerite, the base of which lies next to the coxa, the acute apex reaching only two-thirds the way to the front of the sternum. This reduction in the size of the episternal elements is due to the increase in size of the sternum below and the epimerum above.

The epimerum is enormously developed, extending from the insertion of the hind wings (which is very near that of the anterior pair) back nearly to the middle of the second abdominal segment; it thus forms the side of about half the entire thorax; in situation it is horizontal, its sides vertical, but in front next to the mesocoxæ and sternum it rounds down and under, becoming ventral. (This is a most novel modification of the met-episternum, and as unique as the modification of the mes-episternum in the Odonata.)

Coxæ longer than in the mesothorax, and soldered to the sternum.

Sternum.

The sternal elements are in Forficulidæ remarkably large and broad, the species being essentially runners.

The *prosternum* is subdivided into a single, large intercoxal plate,

which is oblong, widening in front, and with the surface slightly convex, and a præsternal area which is again subdivided into a median rounded area (Figs. 10–12, *p st*) flanked posteriorly by two small triangular sclerites (*p′ st*).

The *mesosternum* is scutellate in shape, nearly as long as broad, wide in front, narrow and well rounded behind the coxæ.

The *metasternum* is entire, very large, broad and rather full on the surface; it is as broad as long, encroaching on the pleurites, and behind is faintly separated by suture from the first urite.

THE ABDOMEN.

There are ten uromeres with ten urosternites (Pl. XXIV, figs. 7–9); the 8th very large, being four times as long as the 7th; the 9th and 10th each forming a pair of lateral scales, at base of each blade of the forceps, being separated by the median sclerites forming the genital armature. The genitals, forming a median, interforcipate, spine-like sclerite, and present above and below, may represent the 11th uromere. The forceps we are inclined to regard as homologues of the cercopoda in other *Phyloptera.*

In regarding as the first uromere the tergite immediately succeeding what we have described as the meta-postscutellum, we differ from what seems to be Professor Westwood's opinion as to the nature of the thorax. He apparently regards this segment or tergite and pleurite (as the sternal portion is not developed) as a part of the metathorax. This segment is a large, broad sclerite closely connected with the metathorax, being slightly excavated next to the metathorax, and rounded behind. On each side it is separated by suture from a narrow pleurite bearing the large, somewhat kidney-shaped first abdominal stigma. The first pair of abdominal stigmata is large and simple, the chitinous edge forming a plain ridge without any projecting teeth. The second pair of abdominal stigmata is visible; the others are not easily detected, as they are minute, but judging by Westwood's figures there are the usual number, *i. e.*, eight pairs. Westwood states that there are three pairs of thoracic spiracles and seven pairs of abdominal ones. Should it be proved that Forficula has a pair of stigmata to each thoracic segment, it will be a remarkable fact, as there is no insect known (Campodea not excepted) which has a pair on each thoracic segment. But we are inclined to think that Westwood has considered our first abdominal uromere with its large spiracles as a part of the metathorax, and thus he considers the number of pairs of thoracic stigmata as three, and of abdominal ones as seven. We have found a large prothoracic spiracle over the coxa on the posterior end under the posterior corner of the pronotum, and concealed on the side by the lateral, scale-like epimerum. We have detected a pair of mesothoracic spiracles, but none on the metathorax.

The result of our examination of Forficulidæ is that they constitute

an ordinal group of Phyloptera, equivalent to the Orthoptera. The larval Forficula is very close to Japyx in the form of the head, the thoracic homonomous segments, in having ten uromeres, in the nature of the forceps, and in the eleventh rudimentary segment. So close is the resemblance that we are somewhat inclined to regard Japyx as a degraded Forficula. When we consider the nature of the head, the elytra-like fore wings, the singular hind wings, which are not net-veined, and the forceps, we see how much unlike the Orthoptera Forficula is. It does not approach Blatta nor Termes. In the character of the wings and the thorax, especially the pleurites, Forficula is suggestive of the Coleoptera, though differing from them in being ametabolous.

In Labia the head is as in Forficula. The body being much shorter and thicker than in Forficula, there are some relative differences from what has been described in Forficula.

Notum.

The *pronotum* is shorter and broader, but still covers the *mesonotum;* the latter is as in Forficula, the scutellum being similarly spine-like. The *metanotum* is as in Forficula, with no important differences; the scutellum is rather more distinct, however, but the postscutellum is much shorter, and has similar, lateral, submembranous folds in front.

The first uromere, with its spiracle, is much as in Forficula, while the succeeding uromeres are much shorter.

Pleurum.

The prothoracic pleurites (episternum and epimerum) are as in Forficula, but shorter and broader.

In the mesothorax the epimerum is much rounded, being, with the episternum, rather shorter than in Forficula.

The mesothoracic pleurites are as in Forficula, but much shorter and wider in proportion.

Sternum.

The sternites are not essentially different from those of Forficula, but are rather shorter and broader.

THE LARVA OF FORFICULA (Pl. XXIV).

The notum of each segment is, as in all Orthopterous larvæ, simple, not being differentiated into scutum, scutellum, etc. On the other hand, the sternites and pleurites are as in the adult, and this proves that the tergites are concerned in and modified by the development of the wings. The episterna are subdivided as in the adult.

In the abdomen there are eleven uromeres, but the first tergite is wanting, the urosternite being present, while the eleventh tergite is small and rudimentary.

Order III. ORTHOPTERA. Plates XXV–XXXVIII.

Blattariæ.

THE HEAD.

Blatta americana ♀. The head is held vertically. The epicranium is broad and smooth; the ocelli are absent or obsolete. The clypeus is broad and short, no suture separating it from the epicranium. The genæ are large, a genal ridge separating the genæ from the orbits. The gula is broad and short.

THE THORAX. (Plate XXVI.)

Notum.

The *pronotum* (Pl. XXVIII) is broad and flat, as long as broad.

The *mesonotum* (Pl. XXX) is remarkably broad and flat, two-thirds as long as broad. The præscutum is wanting (unless represented by a transverse strip in front?). The scutum is flat, consisting of two square sclerites separated slightly by the rudimentary scutellum, which latter is lanceolate, narrow, triangular, and divided into two portions, *i. e.*, the posterior or scutellum proper, which is subquadrate, broader than long, and a narrow, long continuation which reaches to the front edge of the scutum, between its two sclerites.

The postscutellum is represented by a well-marked transverse band behind the scutellum, but not separated from the scutellum by a well-marked suture.

The *metanotum* (Pl. XXX) is like the mesonotum, but with no traces of a præscutum; while the scutellum is much more distinct, diamond-shaped, with distinct sutures, the acute apex not quite reaching the front edge of the scutum; behind clearly demarked from the postscutellum, which forms a definite transverse band.

Pleurum.

The pleurites are very hard to make out, owing to the flatness of the body.

Propleurum. (Pl. XXIX). The episternum is divided into three pieces, the anterior a ridge extending from the sternum to the roof of the scutum; the hinder two a lower piece resting on the trochantine, and an upper, larger and completely chitinous piece extended to the suture. The epimerum is a very irregular, oblong region, partly membranous.

Mesopleurum. (Pl. XXXI.) The episternum in this arthromere is also subdivided into three pieces: the anterior (1) broad and resting on the sternum and reaching around to the epimerum; and (2) a narrow, lanceolate-oval piece not visible from the side; the third sclerite (3) is a broad, triangular piece (which may be the epimerum, but is probably not). A

deep fissure seems to separate the episternal from the epimeral area, and the epimerum rests above the trochantine, being minute, rudimentary, and triangular in outline. The coxa is very large, broad, enormous compared with other Orthoptera; it is much flattened. The trochantine is long and narrow, the suture being on a thin, prominent ridge.

Metapleurum. (Pl. XXXI.) Exactly repeats the mesopleurum in form, but is a little larger, and the coxæ are somewhat larger.

Owing to the much depressed, flattened body, which is correlated to the habit of living under the bark of trees and in cracks, the episterna are only seen from beneath, on each side of the sternum, and the epimera are reduced nearly to a minimum, while the coxæ are enormous, but still flattened, as the Blattariæ are active runners rather than leapers.

Sternum.

The *prosternum* (Pl. XXXI) is well developed, but one-half as broad as long, and submembranous.

The *mesosternum* (Pl. XXXII) is about as broad as long, rounded behind, with a median angular depression.

The *metasternum* (Pl. XXXII) is broader than long, deeply cleft, with a median fold or gore. Owing to this deep, angular depression both the meso- and metasternites can be flexed together, thus allowing the sides of the body to approach each other somewhat.

THE ABDOMEN.

There are in the ♀ eight abdominal tergites, the eighth tergite being deeply cleft, and seven urosternites. The cercopoda are short and 13–15-jointed.

NOTE.—The close relation to Termes and the Termitidæ in general, (a point in which, among other respects, Blatta connects the Orthoptera and Pseudoneuroptera), is seen in the nearly identical form of the episternal and epimeral regions; the latter being dorsal and small, the episternal more developed and sternal in position. The sternal region is much the same in Blatta as in Termes, and judging by the form of the head, thorax and abdomen, these two genera might belong to even the same family. They seem certainly only one family removed, the principal differences being in the wings. If there were, so to speak, no other Orthoptera in existence, the Blattariæ would certainly be associated with the Pseudoneuroptera. Hence we have been almost led to think that it is an artificial classification which places them in separate orders.

MANTIDÆ.

THE HEAD.

Mantis carolina. The position of the head is vertical; the front is broad, triangular. The orbits are very large and broad. The epicra-

nium is divided into an occipito-vertical, square area extending from the occipital foramen and bending over to the ocelli, with a transverse straight suture or impressed line in front extending to the orbits. The clypeus is very distinctly divided into a post- and anteclypeus, the former wider than the anterior division. The labrum is as long as broad and somewhat pointed in front. The genæ are broad, with a marked genal ridge. No gular region in front of the foramen. There is no submentum; the mentum is square, the ligula small and narrow.

THE THORAX.

The thorax, as well as the rest of the body in general, approaches that of Blatta, with, of course, important modifications; in some respects it approaches the Acrydii.

Notum.

The *pronotum* (Pl. XXXIII, figs. 1–3) is remarkably long, forming the tergal and lateral portions of the area. On the anterior fourth is a transverse, impressed line, not, however, quite reaching the sides of the notum; this is situated directly over the insertion of the first pair of legs.

Mesonotum. (Fig. 4, 5.) This is very long, being about twice as long as broad; along the middle extends a sclerite from the anterior to the posterior margin; it is triangular in front and behind; the anterior end we would regard as the præscutum, and the posterior portion as the scutellum, the two uniting on the anterior part of the notum. There is no postscutellum developed. (This union of the præscutum and scutellum is unique in Phyloptera and Neuroptera, but there is an approach to it in Blatta.)

On each side of the front of the notum, and in front of the insertion of the wings, is a distinct, triangular sclerite, the nature of which is uncertain.

The scutum is separated into two long halves.

Metanotum. (Fig. 4, 5.) This is a little longer and slightly narrower posteriorly than the mesonotum, as the hind wings are nearly twice as wide as the anterior pair.

The præscutum is very distinct, narrow, triangular, truncate at the apex. The scutellum is very long and narrow, ending in a long, very acute point before reaching the præscutum; thus the scutum is divided into two long halves, connected by a very narrow bridge, situated between the præscutum and scutellum, while the mesoscutum is entirely divided. The postscutellum is obsolete.

Pleurum.

Propleurites. (Fig. 1–3.) The episternum and epimerum are very small, short, rudimentary, and situated on the anterior fourth of the prothorax.

The *mesopleurites* (Fig. —) are very oblique. The episternum is divided into two sclerites, the upper one-third as long as the lower and scale-like; the lower oblong, narrow, very long, and on the sternal margin bent down next to the sternite. The epimerum is divided into a long, narrow, linear, chitinous portion next to the episternum, the posterior portion lying in front of the metathorax.

Between the lower end of the episternum and coxa is a small, triangular sclerite which I suppose is the trochantine. The coxa is very large, long and quadrangular.

Metapleurites as the mesopleurites, but the sub-episternum is a little wider, and the sur-episternum is longer, while the epimerum is almost wholly membranous. The trochantine? is more distinct than in the mesothorax. The coxa is of the same form as in mesothorax, but a little thicker.

Sternum.

The *prosternum* (Figs. 1–3) is divided into a præ- and poststernite, the latter remarkably long.

The *mesosternum* is narrow, triangular, flat; the apex bordered on each side with a lateral sternal fold of the integument.

Metasternum. A large part of the sternal surface is occupied by the sternal portions of the episterna, which are bent beneath the body. The sternal area is broader and longer than in the mesosternum, but the limits of the sternite itself are less definite; it appears to be a long, narrow, lanceolate-oval area (but this part needs further comparative study, with more material in species than we possess).

THE ABDOMEN.

There are ten segments or uromeres, with ten tergites. The cercopoda arise from the tenth segment. They are stout, many-jointed, and much as in Blatta, only longer. There are but six urosternites. The eight pairs of stigmata are situated on the membranous pleurites.

Remarks. Mantis is a genuine Orthopter in venation as well as in the fundamental structure of the body, and is truly intermediate in its structure between the Acrydii and the Blattariæ, approximating the latter in the structure of the head, mouth-parts, prothorax, the shape of the abdomen, and its appendages. Blatta, in part, may be regarded as the ancestral or stem form of the Orthoptera, from which all the other Orthoptera may have descended; and this accords in the main with the geological succession of the different Orthopterous families so far as we know it.

PHASMIDA.

THE HEAD.

Diapheromera femoratum. Pupa. The head (Pl. XXV, XXVI) is small, narrow, nearly horizontal, subcylindrical. The epicranium is

much developed posteriorly towards the occipital region, being reduced to a minimum in front of the antennæ. The clypeus is very short, undivided, and the labrum is deeply cleft. There is no genal ridge. The gula is rather broad. The submentum and mentum are rather small and narrow.

THE THORAX.

Notum.

The *pronotum* (Pl. XXVIII) is oblong, quadrangular, about twice as long as broad.

The *mesonotum* (Pl. XXX) and *metanotum* are remarkably long and slender, the mesothorax being a little longer than the metathorax, and not differentiated, owing to the want of wings.

Pleurum.

The *propleurum.* (Pl. XXIX.) There are three sclerites on the sides—minute, short, and rudimentary; the anterior is the episternum; the middle the epimerum; and the third and hindermost is the peritreme, bearing the first thoracic stigma; the second pair of stigmata being at the end of the mesopleurum. The coxa is large, cylindrical (a vertical suture along the outer side shows that it is made up of the coxa and trochantine ?).

The *mesopleurum* (Pl. XXXI) is as in the propleurum, but the episternum, as we are disposed to regard it, is larger and extends along, forming a long, very narrow lateral strip, reaching to the prothorax.

The *metapleurum* (Pl. XXXI) exactly repeats the form of the mesopleurum, the episternum in front being somewhat narrower and ending at the mesostigma.

Sternum.

The *prosternum* (Pl. XXXI) is subscutellate, rapidly narrowing in front of the insertion of the legs.

The *mesosternum* (Pl. XXXII) is very long, with a separate piece which we may call the *præsternite,* and which is narrow and crescent-shaped.

The *metasternum* (Pl. XXXII) is as in the mesosternum, but the præsternite is much smaller.

THE ABDOMEN.

There are ten tergites and a rudimentary eleventh. There are nine urosternites. The pleurites are more developed in the ♀ than in the ♂.

THE HEAD.

Prisopus.[151] (Plate XXXIII, figs. 6–9.) The head is as in Diapheromera; the epicranium and clypeus are as described under that genus, but the labrum is less deeply cleft.

[151] A common Brazilian species.

THE THORAX.

Notum.

The *pronotum* (Pl. XXXIII, fig. 6) is one-third longer than wide.

The *mesonotum* (Fig. 7) is very long, though shorter than in Diapheromera. It is entire, with no signs of subdivision into the scutum, scutellum, &c. The presence of the small, net-veined, rudimentary fore wings has not affected or produced a differentiation of the notum, the insertion of the wings being very slightly marked.

In the *metanotum*, owing to the long, large hind wings, with well developed muscular attachments, the notum is differentiated into two lateral swellings, which correspond to two halves of a scutum; while the scutellum is represented by a long, moderately broad area, rounded in front, and at the posterior end narrowed, and with a flattened, boss-like swelling. The scutellum is about one-half as wide as the entire notum, and on the sides it is not definitely separated from the sides of the notum. The hind edge of the notum is emarginate, forming a distinct, rather full ridge extending across the notum. This may represent the postscutellum; but most probably the next sclerite, which I at first took to be the first abdominal segment, is the postscutellum, as the next sclerite bears the first pair of spiracles.

Pleurum.

The pleurites are very much as described in Diapheromera, but the large, long episterna are shorter and broader than in Diapheromera, corresponding with the shorter and thicker proportions of the thorax.

Sternum.

The *prosternum* consists of two sclerites, as in Diapheromera. The *mesosternum* is shorter and broader, but otherwise exactly as in Diapheromera. The *metasternum* is much wider than in Diapheromera, with a narrow, intercoxal oblong area, as in Acrydii.

THE ABDOMEN.

The abdomen repeats that of Diapheromera; counting out the very large meta-postscutellum, there are eleven tergites and eight urosternites. The cercopoda are jointed, short, much as in Mantis.

NOTE.—This genus connects the Phasmida with the Acrydii, Proscopia being the connecting link in the latter family.

Family ACRYDII.

THE HEAD.

Caloptenus spretus. The head, as in the other genera of Acrydii, is compressed so that the front is high and narrow. No signs of an occipital sclerite. In the epicranium the vertex, genæ, and clypeus are well developed. The epicranium extends below the middle of the front, but

not so far down as usual in the other Orthopterous families, though in Tettix it does extend down much farther than in Caloptenus. The clypeus is well marked, one-third as long as broad. The genæ are not very broad; the gula is short and broad.

THE THORAX.

Notum.

The *pronotum* (Pl. XXVIII) is very large, extending to the hinder edge of the mesonotum, and down on the sides as far as the insertion of the legs.

The *mesonotum.* (Pl. XXX.) This and the metanotum, except in the absence of the præscutum, closely resemble the same parts in the Perlidæ. The scutum is short and broad, excavated in front, one-half as long in the middle as on the sides, each side swollen in the middle area, the hind edge deeply excavated to receive the scutellum, which is shorter than wide, obtuse, rounded in front, and behind is a little more pointed. The postscutellum is represented by a narrow, transverse ridge expanding on the sides.

The *metanotum* (Pl. XXX) is as the mesonotum, but a little longer, as the hind wings are larger than the fore pair. The scutellum, with the sutures separating it in front from the scutum, is more distinct; the scutum is a little longer on the median line; the scutellum is rather more acute, triangular in front, and longer and larger than the mesoscutellum. The postscutellum is represented by a simple ridge as in the mesothorax.

Pleurum.

The *propleurum.* (Pl. XXIX.) The episternum is rudimentary, minute, shorter than broad, and triangular. The epimerum is almost obsolete, being represented by a short, ridge-like sclerite. The trochantine is rudimentary, minute, with a large spine. The coxa is a little larger and more swollen sclerite than the trochantine, and is full behind.[152]

The *mesopleurum.* (Pl. XXXI.) The episternum is entire, very large and full, narrowing towards the insertion of the wings, and extending below to beneath the insertion of the legs. The epimerum is of even width, being quite regularly oblong, and only extending to the insertion of the legs above. The meta-spiracle is situated on the posterior, lower angle of the epimerum, while the meso-spiracle is placed on the anterior and upper edge of the episternum. The trochantine and coxa are much as in the fore legs.

The *metapleurum.* (Pl. XXXI). Much as in the mesopleurum, but more oblique, and on the whole slightly larger, as the hind wings are larger. The episternum is narrower below, and much more definitely

[152] In Fig. 13, p. 259 of the 1st Report of the Commission, those parts are wrongly named; the trochantine is the anterior and the coxa is the posterior piece.

separated by an oblique suture from the sternum. The epimerum is less regular in shape than in the mesopleurum, and is more oblique and a little curved. The trochantines are large and longer than those of the two anterior pair of limbs. The coxæ are but slightly developed. The trochanter is oblong, though longer than thick.

In the Orthoptera genuina, Blatta excepted, the trochantines and coxæ are very small, owing to the large pleura and sterna.

Sternum.

The *prosternum* (Pl. XXXI) is short in front, small, broad, triangular, with a scutellate expansion between the coxæ, and a central, long, acute conical tubercle; behind, the sternum expands on each side behind the legs, and is on the same plane as the mesosternum, but separated from it by a well-defined suture; it extends far up on each side of the thorax.

The *mesosternum* (Pl. XXXII) is not so long as broad, but is large, not extending up above the insertion of the middle pair of legs; the surface is a little convex; the hinder edge is excavated, a square portion of the metasternum being dovetailed into it.

The *metasternum* (Pl. XXXII) is wider and longer than the mesosternum, the sides extending up the thorax. The sternum is divided into four parts by sutures; the anterior part has just been described, the posterior is a piece nearly as long and a little wider than the first urosternite, and sends a square portion corresponding to, but smaller than, the one on the mesosternum into the latter sclerite; the two lateral narrow parts lie next to the coxæ.

THE ABDOMEN.

There are ten uromeres (Pl. XXXIV–XXXVIII), represented by ten tergites, and seven urosternites; no pleurites are developed, the eight pairs of spiracles opening on the lower edge of the tergites. The tenth tergite is telson-like, with a triangular pleurite, on each side bearing the cercopoda, which are not jointed. The tenth tergite extends beyond the base of the upper pair of rhabdites.

PROSCOPIA.

THE HEAD.

The high, vertical prolongation of the head in this remarkable insect is a development of the epicranium; the occipital region of the epicranium is also greatly produced, carrying the eyes and insertion of the antennæ much beyond the middle of the head; the space between the eyes is very narrow. The singular, four-angled process projecting above the insertion of the antennæ arises from the vertical rather than from the frontal region of the epicranium, as there is a long space between the insertion of the antennæ and eyes and the clypeus. The latter is very short and divided into post, and anteclypeus, though the two divisions are not separated by a distinct suture. The labrum is deeply hollowed out in front.

THE THORAX.

Notum.

Pronotum. (Pl. XXVIII.) The prothorax is remarkably long, cylindrical, and full in the middle. It is very singular for having no sternum as distinguished from the tergum, but the segment is perfectly cylindrical, with only a fine, lateral, straight suture, which is obsolete behind the legs; while along the sternal region behind the legs there is a median, fine suture. The episternum is present, but no epimerum is differentiated from the tergum. The anterior spiracles are situated on the front edge of the mesothorax, and these are really the usual prothoracic ones, while there is another pair on the hind edge of the mesothorax on the rudimentary mesepimerum.

The *mesonotum* (Pl. XXX) consists of a single oblong sclerite, one third longer than broad, very slightly separated from the pleurum; the surface is rounded and rough like the rest of the segment.

The *metanotum* (Pl. XXX) consists of two portions which have no resemblance to a scutum and scutellum, but which are separated on the side by a diverging ridge extending down the sides into the epimerum; the anterior area is short, transversely broad, while the posterior area is not separated by suture from the anterior, but is as long as broad, and rounded in front. It is interesting to notice the extreme modification of the meso- and metanotum, owing to the absence of wings, and also those characteristics due to the cylindrical form of the body. Proscopia is a link between the Acrydii and the Phasmida.

Pleurum.

The *mesopleurites* (Pl. XXXI) are well marked sclerites, but are still subordinated in form and relation to the cylindrical form of the body. They are oblique, separated by a fine suture from the tergum. The episternum is large and broad, irregular in shape, while the epimerum is much shorter, and not much longer than wide. The pro-peritremes, bearing the prostigmata, are separated by suture from the prothorax, and the meso-peritreme is consolidated with the posterior edge of the mesepimerum.

The *metapleurites* (Pl. XXXI) are much as in the mesothorax, but shorter. The episternum is straight-edged; though oblique in its general position, it is as wide as in the mesothorax, while the epimerum is less than half as wide as the mesepimerum, and the upper portion is reduced to a mere ridge, which extends upon the notum. The metacoxæ are as in Diapheromera, being twice as large as those of the mesothoracic segment, while the procoxæ are a little smaller than those of the metathorax.

Sternum.

The *sternites* (Pl. XXXII) are broad pieces, the meso- and metasternites not separated by suture. The external openings of the mes-ento-

thorax and met-entothorax are conspicuous and situated between the second and third pair of legs.

Conocephalus. In the head of this genus the entire epicranium is produced tergally into a long cone, with no suture above. Beneath, there is a deep inter-antennal fossa dividing the cone from the face, which is longer than broad. There are no ocelli. There is no suture between the clypeus and epicranium, except on the sides.

Family LOCUSTARIÆ.

THE HEAD.

Anabrus. (Pl. XXV–XXVI). The epicranium is very large, and divided into two portions, post- and ante-antennal, which are separated by a short interantennal suture. The front of the head is very broad, and the eyes are small. There is an occipital ridge on the hinder edge, separating the genæ from the ocular region.* The clypeus is trapezoidal, about one-half as long as wide, with an accessory, rounded, anterior expansion on the base of the labrum; the latter rounded, as long as broad. The genæ are broad and flat; the gula moderately broad.

THE THORAX.

Notum.

The *pronotum* (Pl. XXVIII) is very large, extending down to the insertion of the fore legs and backward to the base of the abdomen.

Mesonotum. (Pl. XXX.) The scutum and scutellum are only partially differentiated, the scutal area being represented by two lateral, flattened, slightly-marked bosses on each side of the segment in front, and not separated by suture from the scutellum, whose apex is distinct and acute. There is no præscutum or postscutellum.

The *metanotum* (Pl. XXX) repeats the general features of the mesonotum, but the segment is a little shorter, the scutal bosses smaller, while the scutellum is indicated by a circular, flattened eminence, with no apex behind. The postscutellum is not indicated.

Pleurum.

The *propleurites* (Pl. XXIX) are small and short. There are two episternal sclerites, an upper and lower, of irregular form. The epimerum is undivided; it is no longer than broad, and below laterally flares outward, forming a horizontally-projecting scale. The prostigmata are very large, and the edges are armed within by thick-set spines.

The *mesopleurites* and *metapleurites* are much alike and peculiar in form, being large and high, owing to the small wings. The episternum is long and narrow, and vertical in position; it is undivided, and a little narrower above than near the sternum, the middle being produced into a sharp ridge. The epimerum is as in the episternum, but flatter and only ridged near the sternum.

The *metapleurites* are more oblique than the mesopleurites, and are

a little longer and larger, the entire segment being a little larger than the mesothorax. The coxæ are stout and thick; those of the prothorax spined.

Sternum.

The sternites (Pl. XXXI, XXXII) are peculiar in this genus and family. The *prosternum* is very short and broad; the coxæ are situated rather far apart. The *mesosternum* is divided into two portions; the anterior (præsternite) is divided by a median sinus into two lateral swollen areas, while behind, at the base of each coxa, is a stout, triangular spine.

In the *metasternum* the anterior sternal portion or præsternite merely forms a transverse, curvilinear ridge, from each side of which arises a stouter posterior spine than in the mesosternum.

THE ABDOMEN.

There are ten and perhaps eleven uromeres; nine large square tergites and a tenth narrower one, the tenth segment bearing the small unjointed cercopoda. The supra-anal plate probably represents the eleventh tergite, but it is not separated very distinctly by suture from the tenth uromere. The pleurites are broad but membranous. There are eight pairs of abdominal stigmata, which are situated on the pleurum. Of the sternites, the first seven are small and narrow, surrounded by membrane; the eighth is large and square. The ovipositor is enormous. (The proportion of parts in Phaneroptera is seen in Plates XXXIV–XXXVIII.)

Family GRYLLIDÆ.

THE HEAD.

Gryllus neglectus. The head is rounded, full, vertical in position, smooth, with no areas, although the three ocelli are present. The clypeus is separated by suture from the epicranium; it is divided into two parts, the post-clypeus being short and very broad, and separated on the sides by a well-marked suture from the ante-clypeus, which is considerably shorter and not so wide as the labrum, the latter being one-half as long as broad. The genal ridges are remote and posterior to the orbits. The gular region is unusually broad; the mentum is much shorter and smaller than the submentum.

THE THORAX.

Notum.

Pronotum is broad and flat, square, nearly as long as broad, and bent over the sides, so that the pleurites are very short; posteriorly it overlaps the mesonotum.

Mesonotum is very simple in structure. It is very short, being one-third as long as the pronotum and also one-third as long as the metanotum; the scutum is very short, consisting of two lateral raised areas, nearly separated by the large, broad, swollen scutellum, the latter transversely lozenge-shaped, being rounded in front and a little more angular behind.

Metanotum. On the same plan as the mesonotum, but about three times as long; the scutum is very short and slightly depressed in the middle, enlarging and swollen on the sides. The scutellum is of the same shape as in the mesonotum, but much larger; behind it is a moderately broad, flat band, representing the postscutellum.

Pleurum.

Propleurum. In the prothorax the episternum is represented by two small sclerites, one forming a spine. The epimerum is minute, rudimentary, submembranous. The coxa and trochantine are consolidated into a single, large, thick coxal joint. The prostigmata are rather large and situated on a distinct peritreme.

Mesopleurum. The episternum is divided into three sclerites, the upper much larger than the two lower sclerites, and triangular, with the apex produced towards the insertion of the wings, but not extending up so high as the epimerum. Of the two other sclerites one is supracoxal, and the other is next to the sternum. The epimerum is a large, lanceolate-oval, scale-like, single sclerite, with the posterior edge free, below which is the mesostigma.

Metapleurum. This is much larger than the pleurum of the mesothorax. The episternum is large, oblique, narrow triangular, with the apex extending as far as the upper end of the epimerum; the latter is quite wide, narrowing below; the hind margin is not, however, free.

Sternum.

Prosternum. This is in part rudimentary, and consists of a transverse row of three small sclerites surrounded by membrane, behind which are two larger sclerites, and above, on each side, is a subtriangular piece. Between the coxæ, which are wide apart, is a small, triangular sternite, which sends off long, chitinous angles towards the episternal spines. Behind this is a narrow, long, scutel-like sclerite.

Meso- and metasternum. These are both large, broad, solid sclerites, as long as broad, angulated obtusely on the sides, and notched in the middle of the posterior margin, especially on the metathorax.

THE ABDOMEN.

There are eleven uromeres: eleven tergites, the 11th being the supra-anal plate; the 10th is narrower than the 9th, and situated between the cercopoda, which are large and long and obscurely jointed. The 11th tergite is separated by a faint suture from the 10th tergite. The pleural region is rather broad, bearing the eight pairs of stigmata. There are eight well-developed urosternites; the 7th is twice as long as the basal seven. The 8th is small and rounded behind.

THE HEAD.

Gryllotalpa borealis. The head and prothorax are admirably adapted to the fossorial habits of this insect. The head is long, and rounded

above. The clypeus is very short, the postclypeus less than one-half as long as the anteclypeus. The labrum is long and narrow. The gular region is broad, the genæ small.

THE THORAX.

Notum.

Pronotum. This part is immensely developed, being equal in bulk to the rest of the thorax.

Mesonotum. This is remarkably short, not quite so long as broad, and about one-half as long as the metanotum. There is no præscutum. The scutum is, along the median line, shorter than the scutellum, and is excavated behind in the middle to receive the scutellum, which is rather large and broader than long. There is no postscutellum.

Metanotum. More than twice as long as the mesonotum. The scutum is as long as broad, with a boss on each side above, and a posterior, rather flat area, succeeded by the scutellum, which is broader than long.

Pleurum.

Propleurum. This is represented by an irregularly triangular sclerite, whose apex below bears a stout, downward-projecting spine. The coxa is very thick and rather large, and excavated in front to receive the posterior prolongation of the base of the femur, which is remarkably short, thick, large, and broad, as is the tibia, this and the tarsi being described by other authors.

Mesopleurum. The episternum and epimerum are moderate in width, and oblong; the episternum is broader than the epimerum, and the sclerites are placed vertically and not obliquely.

Metapleurum. The sclerites are large and broad, the sides of this segment being square and vertical, though the sclerites themselves are obliquely situated. The episternum is one large piece resting below on the sternum; the epimerum is as long as the episternum, but narrower. The hinder coxæ are less spherical and swollen than the mesocoxæ.

Sternum.

The *prosternum* is obsolete, being reduced to a narrow membrane situated between the coxæ, which closely meet.

The *mesosternum* is very large and broad, with a curvilinear impressed line between the coxæ.

THE ABDOMEN.

There are ten uromeres; ten tergites, the tenth rudimentary, triangular, short. There are nine urosternites. The pleural ridge is well developed. The cercopoda are long and filamental, thick at base, multiarticulate.

There are no prothoracic stigmata, but the first pair is situated on the back of the mesothorax behind the coxæ; and the second pair on the metathorax behind the epimera and above the coxæ. I can discover only seven pairs of abdominal spiracles.

THE HEAD.

Œcanthus niveus ♀.—The head is long and narrow. The suture between the post- and anteclypeus is obsolete in the middle. The occipital and gular regions are much developed, while the genæ are narrow.

THE THORAX.

Notum.

The *pronotum* is long and narrow.

The *mesonotum* is very short; the scutum almost wanting, very short, while the scutellum is about one-third as long as wide.

The *metanotum* is a little longer than wide; the scutum is shorter than broad, slightly swollen on each side; the scutellum is one-half as long as the scutum, unusually broad, regularly convex, very obtusely angular behind, succeeded by a thin, transverse ridge, which is perhaps the postscutellum.

Pleurum.

The *propleurum* is minute and rudimentary.

The *mesopleurum* is very short and oblique; the episternum is a long oblong sclerite which is moderately broad, while the epimerum is very narrow, but as long as the episternum.

The *metapleurum* is also very oblique, but the two sclerites are of the same width, and both are somewhat broader and larger than the mesepisterna.

Sternum.

All the sternites are broad and full, as indicated in Fig. , so that the coxæ are wide apart.

THE ABDOMEN.

There are eleven uromeres; eleven tergites, and eight urosternites. The cercopoda are long, multiarticulate, while the ovipositor is large, long, and well developed.

Remarks.—This family is evidently closely allied to the Locustariæ, while the Acrydii and Phasmida are closely allied, the Mantidæ standing below next to the lowest group, the Blattariæ.

Order IV. PSEUDONEUROPTERA.

Suborder 1. CORRODENTIA.

PERLIDÆ. Plates XL, XLIV, LVII.

THE HEAD.

Pteronarcys californica. (Pl. XL, figs. 1–2.) No occiput. Epicranium divided into three regions; vertex large and well marked, about one-

fourth as long as broad; eyes on each side; no orbits; the ocellar area separated from the vertex by a well-marked suture, broad, somewhat V-shaped. Separated from the third area in front by a deeply-impressed line.

Clypeus narrow, one-half as long as wide, with a narrow projection in front. Labrum small, narrow, short, and partly fleshy. Genæ of moderate extent. Gula but slightly developed; mentum short, distinct from the submentum.

THE THORAX.

Notum.

Pronotum (*Pteronarcys californica*). (Pl. LVII, fig. 1.) Broad and square, nearly as long as broad.

Mesonotum (*Pteronarcys californica*). (Fig. 2.) Præscutum sub-cordate, rhomboidal, with the posterior half triangular, divided by a deep mesial impressed line; anterior half smooth and swollen. Patagia (?) large and broad.

Scutum very peculiar. It is broader than long, with two large lateral bosses in front, apparently corresponding to the two halves of the scutum in the Neuroptera metamorphotica, and between them is a broad, slightly convex area, which might be regarded as the anterior part of the scutellum, but judging by the limits of the metascutellum it is not.

Scutellum short and broad, well marked behind, but in front insensibly merging into the central flat area of the scutum, with no indications of a suture.

Postscutellum, forming a transverse linear ridge of even width throughout, with very slight indications of an impressed line along the middle of the body.

Metanotum. (Fig. 3.) Exactly repeats the form of the mesonotum, and is, if anything, a little longer than the mesonotum (the hind wings being considerably larger). Only the posterior half of the præscutum in the mesonotum is represented in the metanotum, *i. e.*, the cordate, roughened portion, with the mesial suture. The lateral bosses of the scutum are as far asunder as in the mesonotum. Scutellum crescent-shaped; the suture in front is distinct, whereas in the mesonotum it is obsolete.[153]

Postscutellum a little larger behind the scutellum than in the mesonotum.

Behind the metapostscutellum is a long, transverse, rather broad membrane which connects the metanotum with the abdomen. It is not the first abdominal segment.

Pleurum.

Propleurum (*Pteronarcys californica*). (Pl. XLIV, Fig. 1.) Episternum and epimerum both nearly equally developed; the former subtriangular, the latter subquadrate, and each in part semi-membranous.

[153] In *Acroneuria abnormis* the meso- and metascutellum are not separated by suture from the scutum.

Mesopleurum. (Fig. 2.) The flanks are obliquely inclined. The episternum is divided into a supra-episternite and an infra-episternite; the latter is trapezoidal, a little longer than broad, with a broad projection extending round in front, resting upon the mesosternum. The supra-episternite is sub-diamond-shaped, the lower edge triangular, fitting into the infra episternite.

The epimerum is divided into two pieces; the infra-epimerite is nearly as broad as long; the sub-epimerite is long, oblique, irregular in form, with three large projections from the surface.

Trochantine broad and short. Coxa small compared with the trochantine, being about one-third as large.

Metapleurum. (Fig. 3.) Exactly repeats the structure of the mesopleurum, except that it is a little longer, as the hind wings are larger than the anterior pair. Coxa and trochantine the same as in the mesothorax.

Sternum.

Prosternum (*Pteronarcys californica*). (Fig. 4.) Represented only by a swollen fold in front of the insertions of the legs, and by a gill-bearing membranous swelling behind. In *Acroneuria abnormis* there is a broad, large, scutellate chitinous piece.

Mesosternum (*Pt. californica*). (Fig. 5.) This sternite consists of two portions, (1) a raised, rounded sclerite (præsternite) longer than broad, and situated on the front of the sternal area, between the two anterior gills; (2) behind is the true sternum, which is a very broad, transversely-oblong sclerite, square on the sides, and about one-fourth as long as broad, and somewhat curvilinear. In *Acroneuria abnormis* the mesosternum is divided into (1) a large præsternite, which is broad and triangular; and (2) a large trapezoidal sternite.

Metasternum. (Fig. 6.) The same as in the mesothorax, but slightly larger. Behind the sternite, on both meso- and metathorax, are in each segment two deep fossæ, extending probably into the entothorax (medi- and postfurca). In *Acroneuria* the metasternum is the same in form as the mesosternum, but the *præsternite* is shorter and broader.

THE UROSOME (ABDOMEN).

In *Pteronarcys californica* (Pl. XLIV, figs. 7–9) there are ten abdominal segments (uromeres). The tergites are ten in number, the first broad and well developed, the tenth small and very short, with a median triangular projection (supraanal plate); the segment is entire but very short sternally. There are no pleurites, except nearly obsolete membranous folds on the first and second uromeres, on which the first and second pair of spiracles are situated; on the other uromeres the remaining six pair are situated on the lower edge of the tergites. From the hinder edge of the eighth urosternite two short, stout spines project

backwards. From the tenth urosome a pair of long, multiarticulate cercopoda arise from broad basal joints or flaps, forming lateral anal plates.

PSOCIDÆ. Plate XXXIX, XLIII.

THE HEAD.

Psocus novæ-scotiæ.[154] (Pl. XXXIX, figs. 6–8.) The head is in its structure allied to that of the Perlidæ. Epicranium horizontal, nearly as long as broad, being square on the sides. Ocelli situated close together between the eyes. Clypeus very large and swollen, situated between the antennæ; in front is a semi-membranous division, which may be the ante-clypeus; this sclerite is not quite so wide as the large, broad labrum. The gular region and mentum are broad.

THE THORAX.

Notum.

Pronotum (*Psocus novæ-scotiæ* Walk). Very small, depressed, overlapped by the heade, bing much reduced in size compared with the Perlidæ.

Mesonotum (Pl. XLIII, fig. 10) very high and convex; seen from above, much rounded in front. Præscutum large, prominent, high and rounded, subcordate, but with no mèdian impressed line.

Scutum very short and broad, deeply excavated in front for the reception of the præscutum; each side is much swollen, the swollen areas being separated by the broad median impressed line.

Scutellum small and short, three or four times as wide as long, with a median acute angle in front, and angulated on each side anteriorly; while from each posterior angle a high narrow ridge diverges to the hinder part of the insertion of the fore wing. No postscutellum is visible.

Metanotum (Fig. 11) small, one-half as long as the mesonotum. The præscutum is very small, subtriangular, broad and short, depressed. Scutum one-quarter as long as broad, consisting of two inflated halves, with a median impressed line.

Scutellum minute, rudimentary, somewhat rounded.

Pleurum.

Propleurum. The episternum and epimerum rudimentary, though rather long; while the coxa and trochantine are large and long, being well developed.

Mesopleurum. (Fig. 12.) Episternum and epimerum long and narrow; not oblique, but vertical; the episternum a little thicker than the epimerum.

[154] A large species of Psocus inhabiting coniferous trees in Maine; kindly identified by Dr. Hagen.

Metapleurum. (Fig. 12.) Episternum much as in mesothorax, but the epimerum is narrow, triangular, and reduced to a point next to the trochantine. Coxa and trochantine well developed, rather long and large; the coxa considerably narrower than the trochantine.

Sternum.

Prosternum. Very small, rudimentary.

Mesosternum very small, triangular; the coxæ nearly meeting on the median line of the body.

Metasternum small.

TERMITIDÆ. Plates XXXIX, figs. 1–5; XL, figs. 3, 4, 8; XLI, XLII, XLIII, figs. 1–9.

THE HEAD.

Termopsis angusticollis. (Pl. XXXIX, figs. 1–3.) The head is broad and flat, oblong-oval in shape. The epicranial region is remarkably simple, not subdivided, with no V-shaped suture, and the eyes are very small. The clypeus is very simple, very short and broad; and only an impressed line, no suture, separates it from the epicranium. The labrum is large, one-half as long as broad, and much longer than the clypeus. The genæ are separated from the upper portion of the epicranium by a sharp, lateral, conspicuous ridge. The gular region is small, membranous. The labium is not differentiated into a submentum and mentum.

In *Termes flavipes* (figs. 4, 5) the head is oblong, with faint traces of a V-shaped suture; the clypeus is subdivided into an anterior and posterior portion, the two subequal and well marked.

THE THORAX.

Notum.

Pronotum (*Termopsis*). (Pl. XLIII, fig. 1.) Somewhat crescent-shaped, being excavated in front and rounded behind.

Mesonotum. (Fig. 2.) Remarkably square, as long as broad, with the elements but partly differentiated, an approach to that of Pteronarcys, the slight partial anterior attachment of the wings being correlated with the undeveloped nature of the tergal sclerites. The præscutum is not visible.

The scutellum is not differentiated from the scutum; the latter forming a somewhat swollen flattened boss on each side, but in the middle of the notum contracted, becoming narrow, the region where the scutellum usually is being about a quarter less wide than the scutal region. Postscutellum wanting.

Metanotum. (Fig. 3.) Considerably smaller than the mesonotum, hour-glass shaped, being much contracted in the middle, forming an

anterior or scutal and a posterior or scutellar region. Each side of the scutal region is swollen in front, but the scutellum is not indicated by sutures. Posteriorly the scutellar region spreads out laterally. The wings on both segments are only attached by feeble, local, restricted areas to the front part of the scutum.

In *Termes flavipes* (Pl. XLII, figs. 1–3) there are important differences from Termopsis.

The *pronotum* is one-half as long as the head, well rounded behind, and one-fourth shorter than broad.

In the *mesonotum* the scutum and scutellum are differentiated; the scutum is broad and short, one-half as long as broad, and rounded behind. The scutellum is quite free from it, and is larger than the scutum, being longer, with the sides prolonged toward the posterior insertion of the wings.

In the *metanotum* (Fig. 3) the scutum is very broad and short, shorter than the mesoscutum, and only two-thirds as long as the metascutellum; the latter is large and broad, being a little shorter than broad. No præ- or postscutellum in either segment.

The meso- and metanotum are considerably narrower than the thorax itself, and are margined with membrane, the insertion of the wings being tergal and very weak.

Pleurum.

Propleurum (*Termopsis angusticollis*). (Fig. 4.) The sides of the prothorax are much flattened, as if (seen from above) the body had been squeezed and the flanks pressed out, so that they present a rather wide lateral area on each side of the tergites. The episternum forms a narrow (vertically) linear piece. The epimerum is membranous, narrow, but wider than the episternum. The coxa and trochantine are consolidated in one large oval-oblong sclerite.

Mesopleurum. (Fig. 5.) Episternum forming one large, irregular piece, expanding above the middle, anteriorly forming a triangle. The epimerum is much smaller and semi-membranous. The trochantine is large and long, being oblong-ovate; coxa as long as the trochantine, but narrower, and pressed up (so to speak) beyond it.

Metapleurum. (Fig. 6.) Much shorter than that of the mesothorax. Episternum much narrower, while the trochantine is broader and much shorter in proportion; otherwise much as in the preceding segment.

In *Termes flavipes* (Fig. 4) the pro-episternum is represented by a narrow sclerite situated in front of and below the pronotum, and separated from the sternites by a suture. The epimerum is a minute, triangular sclerite situated over the coxa. The trochantine is large and long, and the coxa is of the same length.

Mesopleurum. (Fig. 5.) The episternum is well developed, narrow, curved, triangular. The epimerum is much smaller, and both pieces are situated obliquely. The trochantine and coxa are of the same size and

length, and are unusually free from each other, the two sclerites together forming a very broad and thick portion for the attachment of the legs.

Metapleurum. (Fig. 6.) Much as in the mesopleurum, with the coxa pointed at the lower and posterior end; both the meso- and metapleurites are more oblique than the propleurites, while the meta- are fully as large as the mesopleurites.

Sternum.

Termopsis. (Fig. 7.) The prosternum is triangular, about as long as broad.

The mesosternum is about three times as large as the prosternum, and also equilaterally triangular, with the posterior apex acute. Metasternum?

Termes flavipes. (Figs. 7–9.) The prosternum is rudimentary, consisting of four sclerites; two large ones next to the episternum in front, and two minute triangular ones behind. The meso- and metasterna are entire, broadly triangular, and rather large, with a pair of accessory sclerites in front of the coxæ. The coxæ seen from beneath are divided by a deeply-impressed longitudinal line.

THE ABDOMEN.

The abdomen of *Termopsis* is much as in Blatta; it is very flat, broad, oval-oblong; ten uromeres, the first tergite broad and long; the tenth

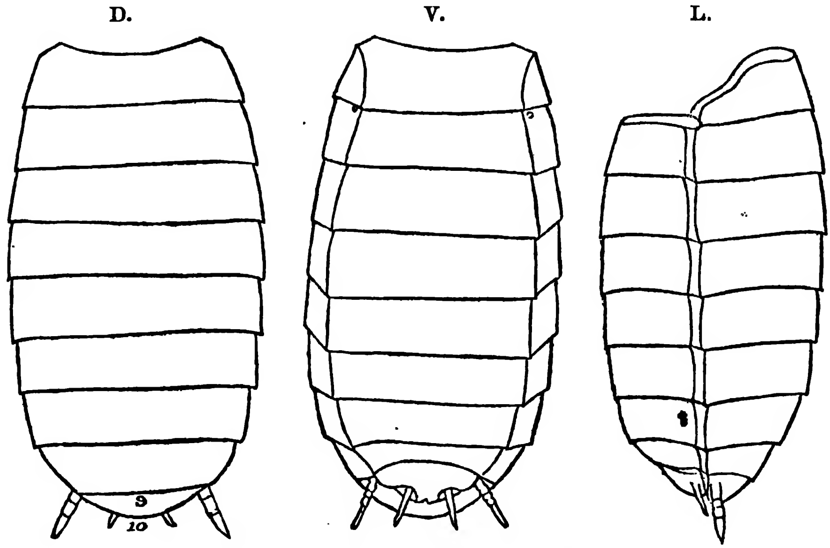


FIG. 12.—Abdomen of Termopsis angusticollis. D, dorsal; V, ventral; L, lateral view. Enlarged Gissler, del.

short, triangular, small, only extending between the short five-jointed cercopoda. There are nine urosternites. The pleurites of the abdomen

(uropleurites) are only seen from beneath, but are well developed. The abdomen of *Termes flavipes* is substantially as in Termopsis.

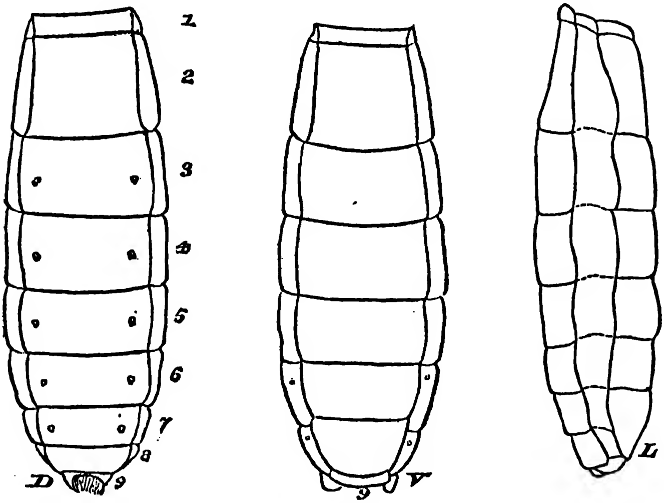


FIG. 13.—Abdomen of Termes flavipes. Lettering as in fig. 12. Enlarged.

Suborder 2. ODONATA. Plates XLVII–L.

THE HEAD.

Agrion verticale Say. (Pl. XLVII, figs. 4–6.) The structure of the head of Agrion and Calopteryx is more easily understood than that of Æschna and Libellula, as their eyes are much smaller, and the development of the epicranium is more equable and normal. The head is unusually short and wide; the orbits very wide; eyes spherical. The epicranium, exclusive of the orbits, is about as long as broad, with a decided ocellar area, the ocelli being large and closely contiguous. In front of the ocelli is a deep impressed line parallel to the clypeus.

The clypeus is moderately large, about one-half as long as broad, with a high, sharp, shelf-like side; it is divided into a clypeus posterior and anterior; the post-clypeus being horizontal like a shelf, and the anteclypeus forming a vertical wall.

The labrum is large and broad, well rounded in front. The genæ are very large and broad, smooth, and continuous with the orbits. The gula is membranous.

In *Calopteryx maculata* the head is much as in Agrion, but the clypeus is more clearly defined and separate from the epicranium than in Agrion. The epicranium is wider and larger than in Agrion; a transverse impressed line separates it into a posterior and anterior area.

In *Æschna heros* (Pl. XLVII, figs. 1–3) there is no definite trace of the occiput, unless a postorbital ridge between the gula and orbits marks its limits. This ridge becomes obsolete towards the median line near the

vertex. As the eyes are enormous and meet on the median line of the head, the epicranium is divided by them into three portions: 1, a narrow orbito-gular area, not seen from above; 2, an ocello-antennal, very small, subtriangular area; and 3, a pre-antennal, large area, corresponding to the small ante-antennal area in Agrion. This area, with the clypeus, forms the peculiar shelf-like projection of the front of the head. The area is divided into a horizontal broad area and a transverse crescent-shaped subarea, separated from the horizontal portion by a sharp ridge. The clypeus is very large and full, reaching from eye to eye, and nearly as long as broad. It is separated from the epicranium by a well-marked curvilinear suture. In front it incloses the ante-clypeus, which is a crescent-shaped sclerite no wider than the labrum, and separated by a distinct suture from the clypeus proper.

The labrum is large and broad, very distinct from the clypeus.

THE THORAX.

Notum.

The Odonata are characterized by the unusual development of the pleurites, the meso-episternum forming the larger part of the dorsum of the thorax, the meso- and metanotum being greatly reduced in size, owing to the great and long-sustained powers of flight possessed by these insects.

In Agrion the *pronotum* (Pl. XLVII, fig. 10) is well developed compared with the meso- and metanotum; somewhat broader than long, divided into three areas, being emarginate in front and behind, with the edges turned up, while the large central area has two lateral, slightly swollen areas.

Mesonotum. (Fig. 11.) The præscutum not visible; scutum entire, minute, not much longer than wide. The scutellum is a much swollen rounded knob, with the base subtriangular, not much smaller than the scutum. The post-scutellum appears to be a moderately broad, even, two-ridged, transverse band.

The *metanotum* (Fig. 11) repeats the general appearance of the mesonotum and is of the same size, the wings being alike. The præscutum is not visible. The scutum is deeply divided into two halves, each half minute and much swollen. The scutellum as in mesonotum, but considerably larger. The post-scutellum is very distinct, forming a transversely-oblong piece no wider than the scutellum.

Calopteryx (Pl. XLVIII, figs. 5–6) is substantially as in Agrion, as regards the notum.

In *Æschna heros* the *pronotum* is small and narrow, and nearly concealed from above by the head. It is about two-thirds as long as broad, divided into a short transverse ridge and a posterior, longer portion subtriangular behind, by a deep constriction or impressed line.

Mesonotum. (Pl. XLVIII, fig. 3.) The præscutum obsolete, not visi-

ble from above. Scutum subtrapezoidal, longer than broad; acute behind, with an appendicular area between the conical end and the scutellum, consisting of two diverging tubercles, from which a narrow ridge falls away on each side, forming the origin of the 5th vein of the wings on each side. (Fig. 3, v. 5.)

The scutellum is swollen, triangular, as broad as long, the apex directed backwards and wedged in between the separate halves of the post-scutellum, which is represented by two triangular bosses, the apices separated by the pointed end of the scutellum, the bases connected by a ridge concealed by the end of the scutellum.

Metanotum. (Fig. 4.) There is a pair of patagia, one in front of the base of each hind wing. No præscutum. The scutum is much larger than the mesoscutum, a little longer than broad; each side raised into an oblong-oval boss, with a narrow, acute, triangular, depressed, flat area between, and bounded behind by a converging ridge, which is succeeded by a peculiar diverging ridge (v. 5), like that in the mesonotum, which is the origin of the 5th vein of the second pair of wings.

The scutellum is much larger than in the mesonotum, nearly square, smooth and flat; the posterior one-half vertical, thin, and more or less elastic and membranous, moving upon the abdomen. (This posterior portion may represent the post-scutellum, which is otherwise absent, but there are no signs of a suture.) Post-scutellum absent (?) See Fig. 4, p. scl.'', for what may prove to be the post-scutellum.

Pleurum.

In *Agrion* (Fig. 7) the pro-episternum and epimerum of each side are minute, rudimentary, and submembranous, and in position are vertical,

Mesopleurum. The episternum in the Odonata differs remarkably from all other Pseudoneuroptera and indeed from all other insects, only the Acrydii approaching them in the enormously long and large episterna, which meet in front to form a large, dorsal, convex area, that usually occupied in other insects by the scutum. The epimerum is a similar piece, and nearly as large as the lateral portion of the episternum; it is in Agrion consolidated with the meta-episternum. In Calopteryx, however (Fig. 6), where the thorax is broader and higher, the two sclerites are separate.

The coxæ are small, conical; the trochantine is small, triangular, and situated directly over the small conical coxa.

Metapleurum. (Fig. 8.) The episternum repeats the form of that of the mesopleurum, but is consolidated with the meso-episternum. The episternum, seen laterally, is regularly oblong, and three times as long as broad.

The trochantine is a triangular piece, situated directly over the small subconical coxa.

In Calopteryx (Fig. 6) the meso-episternum and epimerum are much

as in Agrion; those of the metapleurum are much as in the meso-, but a well-marked suture separates the meso-epimerum from the meta-episternum, and the latter is much wider towards the insertion of the wing than next to the coxa.

In the prothorax of Æschna the episternum is very small, and subdivided into several pieces; the epimerum is larger and not divided; it is about as long as broad, and posteriorly submembranous.

The coxa is very large, being much enlarged within, meeting the opposite coxa on the median line.

Mesopleurum (Fig. 1) enormous, and forming a large part of the dorsal region of the thorax. The episternum is enormous, forming with its fellow on the opposite side a large proportion of the front and mesonotum; the foramen leading into the prothorax is situated very low, the mesostigmata being situated on the upper side of the opening. The two meso-episterna unite to form the front of the mesothorax and also the anterior fourth or third of the dorsal region of the entire thorax. Dorsally there is on the united episterna a high median ridge becoming forked behind, with two lateral diverging transverse ridges. The ridge originates in front from the hinder border of a transverse crescent-shaped area directly above the foramen leading into the prothorax. A straight, distinct suture separates the episternum from the epimerum. Between the episternum and the trochantine is a sclerite, the nature of which is uncertain; by its close relation to the sternum it may be the infra-episternum and probably not the coxa, the latter appearing to be obsolete.

The epimerum is large, broad, oblique, and below in front of the metastigma separated by suture from the meta-episternum, but above there is no suture, only a broad, valley-like depression.

Metapleurum. The episternum is about one-half as wide as the large, swollen, smooth epimerum, which composes the posterior third of the pleurum of the thorax. Below the metastigma is a square sclerite, directly over the trochantine, which is probably the infra-episternum, there apparently being no coxa; the trochantine as in the prothorax.

Sternum.

In Agrion the prosternum is small, triangular, longer than broad, with the apex acute.

Mesosternum a little larger and broader than the prosternum, but still small.

Metasternum. What I am disposed to regard as this sclerite is a very large, elongated, polygonal area, which is semi-membranous and flat.

In Calopteryx the sternites are as in Agrion, but the metasternum is broader and shorter, with an anterior deeply impressed median line.

In Æschna the mesosternum is small, broad, irregular; while the metasternum is much smaller, nearly obsolete in front of the legs,

and behind is a broad, sternal, large area, broader and shorter than in Agrion.

It should be observed that in Odonata the middle and hind legs are close together.

THE ABDOMEN.

In *Agrion* (Pl. L, figs. 4–6) there are ten uromeres. The first tergite is well-developed, the second one-half as long as the five succeeding tergites. No pleurites, the tergites overlapping the urosternites, which are very narrow. The tenth urosome shorter than broad. The claspers possibly represent an eleventh urosome, as such a segment is developed in the embryo, but in the adult the claspers appear to be appendages (cercopoda) of the tenth urosome. Calopteryx closely resembles Agrion as to its abdomen.

In Æschna (Pl. XLIX, L. figs. 1–3) there are ten uromeres; and the rudiments of an eleventh urosternite; the cercopoda (*c*) are long and spatulate.

Suborder 3 EPHEMERINA. Plates XLV, XLVI.

THE HEAD.

Ephemera.—It has been difficult with the material at my command to properly describe the external anatomy of any member of this group. The species examined was our commonest Ephemera in Rhode Island, identified by Dr. Hagen as probably *E. cupida* (Leptophlebia) Walk., and also aspecies of Palingenia. There is a great deal of variation in the form of the thorax and head in the genera of this suborder, which is as much specialized in its way as the Odonata is in its.

In examining the under side of the head of an alcoholic Ephemera, the subject of the drawing made by Dr. Gissler (Fig. 2), there is a cavernous area, at the bottom of which I can discover what appear to be the rudiments of the maxillæ and labium. There are certainly no rudiments of the mandibles. The gular region and the mentum can be distinguished, and I think I can detect the labial palpi and lingua; concerning the maxillæ I am less certain. The drawing was made by Dr. Gissler from but one specimen, and while correct in most respects he regards the sketch of the mouth-parts as provisional. The general relations of the under side of the head are as he drew them, with one or two corrections made by the writer.

In an alcoholic specimen of *Palingenia bilineata* (perhaps a subimago) I can discover no certain rudiments of any of the mouth-parts. The under side of the head forms a deep hollow, and the mouth region is a deep pit, bounded by a high, thin wall in front—the lower edge of the clypeus. This pit is open to the roof of the mouth or clypeus. It is impossible to distinguish the rudiments of any of the mouth parts, and practically they appear to be wholly obsolete.

THE THORAX.

Notum.

This region of the body is more highly concentrated than in any other Phyloptera, not excepting the Trichoptera. The prothorax is a rather wide collar, longer and broader than in the Trichoptera, but the mesothorax is spherical and very large in proportion to the metathorax, which is rudimentary and but slightly developed; owing therefore to the large mesothorax and the small pro- and metathorax, the entire thorax is oval-elliptical, and much consolidated, thus approaching in its general appearance the general shape of the Tipulid thorax, or that of the lower Lepidoptera.

Pronotum. This forms a broad collar extending backwards on each side, the hinder edge being excavated in the middle.

Mesonotum. This is long and well developed, not so wide as the body, the flanks extending out, when seen from above, beyond the sides of the notum. The præscutum is well developed, forming a round, convex, swollen sclerite as long as broad, with a median suture-like impression. The scutum is very large and long, oval, about one-third longer than broad, slightly broader behind than in front.

The scutellum is large and well developed, irregularly scutellate in outline, with two bosses in front; the posterior end is narrow, truncate at the end, with the surface at the end somewhat swollen.

Metanotum. The metathoracic segment is small, very short, and the notum and sternum, as also the pleurites, are somewhat rudimentary. The surface of the notum is somewhat depressed below the level of the mesoscutellum. It is difficult to describe the sclerites, which are represented in Fig. 1. The entire segment is about one-third as long as broad. The scutum is not well differentiated, being represented by a median irregular area (Fig. 1 *sc''*) about half as long as broad. No scutellum and postscutellum can be distinguished with certainty.

Pleurum.

The sclerites of the flanks are difficult to distinguish. In their development and arrangement the Ephemerina differ from all other Phyloptera.

Mesopleurum. Though there are a number of sclerites in the mesothorax it is difficult to distinguish what are properly episterna and epimera. The region of the mesepisternum is indicated in Fig. 2 *epis''*, and is much larger than the epimeral, which is the region situated over the insertion of the middle pair of legs.

The first pair of spiracles is situated on the mesothorax under and in front of the insertion of the first pair of wings; the second pair is situated on the metathorax directly under the insertion of the second pair of wings.

In the *metapleurum* the episternal region is quite limited and minute compared with the large mesepisternal region; what I am inclined to

regard as the epimerum appears to be the sclerite *e m''* (Fig. 2), which in the sketch is situated directly under the metanotum.

Sternum.

Prosternum. This is a small triangular area situated between the insertion of the legs.

Mesosternum. This is a very large region divided into a præsternite and sternite. The former is narrow, as long as broad, the surface convex. The sternite is divided into two large, long, oval portions extending far back of the insertion of the legs.

Metasternum. This sclerite is very short, small and rudimentary.

THE ABDOMEN.

There are ten abdominal segments. The first tergite is wanting, the tenth is a supra-anal plate. There are nine urosternites; the basal is large and long, with a pair of spiracles. The 11th uromere may be represented by the median articulated appendage situated between the two very long multi-articulated cercopoda. The 10th urite is represented by two long, oval, parallel plates.

A remarkable feature of the male Ephemerina is the two pairs of jointed appendages rising from beneath the cercopoda. These may be regarded as homologues of two pairs of the rhabdites composing the ovipositor of the female of other insects. The lower pair (Fig. 1 *rh*) is 3-jointed (perhaps 4-jointed), while the upper pair (*rh'*) is 2-jointed. We know of no other insects which have two pairs of jointed claspers. These singular organs may be called *rhabdopoda.* They appear to be homologues of the abdominal feet of Myriapods, the abdominal legs of Tenthredinid and Lepidopterous larvæ, and the spinnerets of spiders.

The adult Ephemerina, then, in the lack of mouth-parts, in the concentrated thorax, and the possession of two pairs of abdominal jointed appendages, differ remarkably from the Odonata and other Phyloptera, so that we are nearly justified in regarding the group as entitled to rank as a suborder.

Order NEUROPTERA (as restricted by Erichson).

Suborder 1. PLANIPENNIA.

Family SIALIDÆ.

THE HEAD.

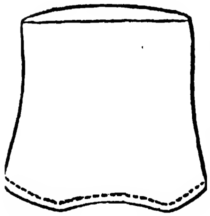
Corydalus cornutus. (Pl. LII, figs. 1–3.) Head very broad and flat; vertex remarkably large, broad, long, and flat, forming the bulk of the epicranium. Ocelli three, large, but the ocellar area is small, with no suture; the ante-antennal (orbital) fossæ large and conspicuous, transversely oval above, beneath curvilinear. No suture between the clypeus and

epicranium, the very broad clypeus being indefinitely bounded behind, the front edge projecting over and concealing the short, broad labrum, and the edge thickened and tridentate. Mandibles of male enormous, their base partly covered by the clypeus. The genæ are very large and broad, bounded (in part) in front by the ante-antennal curvilinear fossæ. The gula is solid, long, and narrow, extending from the occipital suture to the mentum, there being no submental suture; lateral sutures separate the mentum plainly from the gulæ; submentum very broad. The occiput is present, appearing as a short and broad area, with a median, transversely-oblong sternite forming the base of the gula. (See larva.)

Raphidia oblita.[154] (Pl. LI, fig. 5–7.) Head as in Corydalus, but the vertex is longer in proportion and the clypeus, being smooth, is better limited. The ocelli are either present or absent, and there is no distinct area. The labrum is large, the clypeus not concealing it. There are no fossæ. The genæ are very large, meeting over the gula, which is obsolete, except in front, where it is broad and triangular, and forms a submental region. The occiput is apparently well marked, forming the neck, and with a suture in front.

THE THORAX.

Notum.


Pronotum of Corydalus, enlarged.

Pronotum (*Corydalus*). Large and square, about as long as broad; full in front and sinuous behind; somewhat hollowed in the middle.

Raphidia. (Pl. LIV, fig. 10.) Long and narrow, rectangular, very slightly excavated in front, and pointed behind.

Mesonotum (*Corydalus.* (Fig. 12). Præscutum broadly subtriangular, shorter than in Raphidia, but more distinct. Scutum completely cleft, the præscutum and scutellum touching; each division of the scutum subquadrate. Postscutellum large and long, very wide, and well developed.

Raphidia. (Pl. LIV, fig. 11.) Præscutum well developed, larger, but otherwise as in Corydalus. Scutum completely cleft, so that the præscutum meets the scutellum; the latter shorter than broad, obtuse at the apex in front, being subtriangular. Postscutellum well developed, wide, and of nearly the same length throughout, but incised in the middle to receive the scutellum.

Metanotum (*Corydalus*). Præscutum much as in Raphidia, but smaller; scutum not entirely divided; scutellum triangular, less acute in front than in Polystœchotes, but more so than in Raphidia. Postscutellum well developed, transversely linear.

[154] *Raphidia oblita* Hagen, from California.

Raphidia. (Pl. LIV, fig. 12.) Præscutum present, but obscurely marked, being almost obsolete, but the outline is seen to be triangular. The scutum is large, only half divided by the scutellum, which is much shorter than broad, but triangular in form. Postscutellum forms a narrow, transverse band, which is shorter than in the mesonotum.

Pleurum.

Corydalus. In the *propleurum* (Pl. LXIV, fig. 1) the episternum and epimerum are minute, rudimentary, and not well defined; owing to the great size of the sternite no trochantine is visible. The coxa is large and thick, about twice as large as the succeeding coxæ.

Raphidia. (Pl. LIV, fig. 13). Much as in Corydalus; the episternum and epimerum are minute and rudimentary, the relative form of these sclerites not being easily made out. The coxæ, however, are long and thick, and much larger than those of the meso- and metathorax.

In *Corydalus* (Fig. 2) the meso-flanks are rather short and thick; the supra-sternite square. The episternum is a little longer than broad; the suture between it and the sternite is obsolete. The epimerum is moderately long, widening considerably towards the insertion of the wings. The coxa is very short and thick. The trochantine is very small; one-half as large as the coxa.

Raphidia. (Pl. LIV, fig. 14.) The mesopleurites are just as in Corydalus, but longer and slenderer, and the suture of the sternum is well marked. The epimerum is longer and narrower above than in Corydalus, and the trochantine is small; coxa moderately large.

Metapleurum (*Corydalus*). (Fig. 12.) The flanks of the metathorax are longer, *i. e.*, thicker, than in the mesothorax; being also shorter vertically. The episternites are shorter vertically, but thicker, and the coxæ are shorter and thicker. The epimerum is undivided, not so wide above (next to the insertion of the wings) as in the mesothorax. The trochantine is a little smaller than in the mesothorax.

Raphidia. (Pl. LIV, fig. 15.) As in Corydalus, the metapleurites are decidedly thicker and longer than the pleurites of the mesothorax. The episterna are both larger and thicker than in the mesothorax. The epimerum is not divided, narrower below, and wider towards the insertion of the wing than in the mesothorax. The coxa is nearly twice as large as in the mesothorax.

Sternum.

Corydalus. The *prosternum* (Fig. 4) is remarkably large, square, with an anterior, short, separate piece, or præsternite.

The *mesosternum* (Fig. 5) is large and very broad, transversely sub-oblong, the suture between it and the infra-sternite only partial.

The *metasternum* is as in the mesothorax, but a little larger (Fig. 6).

Raphidia. The *prosternum* (Pl. LIV, fig. 16) is very large, long, and narrow oblong antero-posteriorly, and is covered by the bent-down

tergite. The *mesosternum* (fig. 17) is large, each half subrhomboidal and passing laterally, forming a ridge between the sur- and infra-episternites. The *metasternum* (fig. 18) is much as in the mesosternum, there being no special difference in form or size, since the meso- and metathorax are of the same size.

THE ABDOMEN.

Corydalus. The ♂ abdomen (Pl. LVII, figs. 4–5; Pl. LVIII, fig. 1) is not very long, but broad and thick; ten uromeres; ten tergites, the tenth rudimentary and conical, concealed by the large ninth tergite, which is cleft, and bears two pairs of large, long claspers, which are jointed to the tergite. The pleurites are narrow, membranous. There are eight urosternites, the eighth cleft along the entire length.

Raphidia. The ♀ abdomen is moderately long, broad, spindle-shaped. There are ten uromeres; ten tergites, the tenth small. The pleurites are well developed, but narrow, bearing the spiracles. Of the urosternites, seven are well developed, and the ovipositor is remarkably well developed, more so than in any other Neuroptera (Pl. LVIII, fig. 5–7).

HEMEROBIIDÆ.

THE HEAD.

Ascalaphus.[155] (Pl. LI, figs. 3–4.) The head is held vertically; it is broad and short; the eyes are very large, approaching the Odonata in this respect, and are double. The epicranium is small and narrow on the vertex, owing to the large eyes, which nearly meet above. The orbits are very wide in front of the eyes; the clypeus broad, double, being divided into an anterior and posterior clypeus; the latter is smooth and flat, transversely oblong, limited on the sides by two deep linear fossæ; the anteclypeus narrows in front and is broadly trapezoidal, but is considerably shorter than the postclypeus. The labrum is broad and very short, the front edge a little excavated. The genæ are large, full, and swollen. The gular region is depressed, moderately wide.

Myrmeleon diversum Hag.[156] (Pl. LI, figs. 1, 2). The head is short and moderately broad; the vertex is full and swollen on each side of the median furrow. No ocelli, and no ocellar area, the latter region being sunken and obsolete. There are two deep, ante-antennal, linear, orbital fossæ in front at the base of the clypeus. There is no well-marked clypeal suture. The clypeus is a little shorter than broad, the posterior and anterior divisions being slightly indicated by a ridge. The labrum is short and broad. The gula is broad and membranous.

Polystœchotes nebulosus. (Pl. LI, figs. 8–10.) The head is of the same shape as in Myrmeleon, but the vertex is entire, full, and convex. Ocelli wanting, but the ocellar area is full, raised, though not well defined.

[155] *A. longicornis?* from New Jersey.

[156] The specimens examined were from Colorado. I am indebted to Dr. H. Hagen for the identification of the species.

The orbits are large. The orbital fossæ are round, but not so distinct as in Myrmeleon. The clypeus is as long as broad, the sutures more distinct than in Myrmeleon; the median transverse ridge is more distinct than in Myrmeleon. The post- and anteclypeus are nearly equal in size. Labrum as in Myrmeleon. The gula is broad, membranous.

Mantispa.[157] (Pl. LII, figs. 4–6.) The head is held vertically, and is as broad as long. The epicranium is broader than long, rather flat, with no V-shaped suture or ocellar area. The clypeus is large, very distinct, nearly as broad as long, square at the base, but constricted in the middle. The labrum is large, broader than long, much rounded and produced in front. The genæ are broad, and the gular region is rather narrow, but moderately so compared with Corydalus. The submentum (?) is large, and nearly as long as broad. The ligula is very large and long, spatulate, not divided, and very simple compared with Corydalus.

THE THORAX.

Notum.

In *Ascalaphus* the *pronotum* (Pl. LVI, fig. 1) is short and small, divided into two halves by a deep median suture. In its shape it approaches that of the Odonata more than any other true Neuroptera.

Myrmeleon. (Pl. LIV, fig. 1.) It is square, much excavated behind and full in front, a little narrower than long.

Polystœchotes. (Pl. LVII, fig. 8.) It is one-half as long as broad, and is a little excavated in front and behind.

Mantispa. It is very long, being twice as long as its greatest breadth, subpyriform in outline, nearly twice as broad in front (full on the front edge) as behind. It is excavated behind (Pl. LV, fig. 1).

The *mesonotum*. *Ascalaphus.* (Pl. LVI, fig. 2.) The præscutum is large with the central portion subcordate, larger than in Myrmeleon. The scutum is almost entirely divided. Scutellum large and swollen, apex very obtuse; the postscutellum forms a transverse, flat ridge.

Myrmeleon (Pl. LIV, fig. 2.) Rectangular in outline. The præscutum is very large, as long as broad, and much as in Polystœchotes. The scutum is not deeply cleft, the median third being entire. The scutellum is small, subtriangular, broad, and with the apex obtuse, while the side sclerites are large, as in the metanotum. Postscutellum?

Polystœchotes. (Pl. LVI, fig. 9). The præscutum is very large, being nearly as large and wide as the scutum, and divided by a median furrow; each half full and rounded in front. The scutum is completely cleft, the præscutum and scutellum touching; each side of the scutum is squarish. The scutellum is broader than long, very acute, being produced in front, forming a long point. The postscutellum is rather large and very wide, being divided by a median suture.

Mantispa. (Pl. LV, fig. 2.) Præscutum minute, nearly obsolete, not

[157] *Mantispa brunnea* Say, from Utah; identified by Dr. Hagen.

visible from above. The scutum is, however, much larger than in any other genera of Neuroptera (restricted), being only cleft on the posterior one-fifth. The scutellum is very short and broad; one-fourth as long as broad, with a linear, depressed, acute apex. The postscutellum is not visible from above, and is only seen by examining the posterior aspect of the segment in dissected specimens.

The *metanotum* (*Ascalaphus*). (Pl. LVI, fig. 3.) Much smaller than the mesonotum. The præscutum is unusually large, with a swollen cordate portion. The scutum is entirely divided, the two halves widely separated, the præscutum and scutellum meeting, the point of juncture being very wide.

Myrmeleon. (Pl. LIV, fig. 3.) The præscutum is large, excavated in front, though not so large as in Polystœchotes; it is wider than the scutellum. The scutum is entirely divided into halves, so that the præscutum and scutellum touch each other. The scutellum is very full and rounded behind, as long as broad, not being triangular; the side pieces are large, seen from above.

Polystœchotes. (Pl. LVI, fig. 10.) Præscutum? The scutum is completely divided by the scutellum, which is acutely triangular. Postscutellum?

Mantispa. (Pl. LV, fig. 3.) The præscutum obsolete, not visible from above. The scutum is larger than usual, but only cleft on the posterior fourth of its length; the scutellum is short, acutely triangular in front, but very broad, and the sides in front are sinuous; it is smaller and narrower than in the mesonotum. The postscutellum is not visible unless the specimen is dissected, when it is seen to form the back of the segment.

Pleurum.

Propleurum (*Ascalaphus*). The pleurum is hard to describe from a single specimen, but the sclerites are much rounded, full, and swollen; the mesothorax is nearly one-third longer and thicker than the metathorax, while the thorax as a whole is spherical and much consolidated.

Myrmeleon. (Pl. LIV, fig. 7.) The episternum is nearly twice as large as the epimerum. The coxæ are very large and long.

Polystœchotes. The episternum is not so much larger than the epimerum as in Myrmeleon, but the coxæ are longer and slenderer.

Mantispa. The pleurites are very small; the episternum is very small, irregularly oblong; the epimerum is subdivided, small, narrow, but a little more regular and larger than the episternum. Coxæ very large and long; the trochantine submembranous.

Mesopleurum (*Ascalaphus?*).

Myrmeleon. (Pl. LIV, fig. 8.) The flanks are very broad and short, as a whole. The suprasternite present, very short and broad, equilaterally triangular in outline. The episternum is remarkably short and broad, triangular, being two-thirds shorter than in Polystœchotes. The

coxa is large, much broader than long, subrhomboidal. The mesostigmata or their peritremes are situated each on the front and upper angle of the supra-sternite directly in front of the fore wings.

Polystœchotes. (Pl. LVI, figs. 8–15). The pleurites are not so broad and short as in Myrmeleon. The supra-sternite is considerably longer than broad, the apex toward the wings being conical. The episternum is vertically oblong, quite regular, being considerably longer than broad. The epimerum is moderately broad, square below. The coxa is moderately long, longer than broad; the trochantine regularly conical.

Mantispa. (Pl. LV, fig. 8.) The flanks of the meso- and metathorax are of the same size and general appearance. The episternum and epimerum are each subdivided more or less regularly into two sclerites. The epimerum as a whole is not so wide as the episternum. The coxa is large, full, conical; the trochantine is minute, short, triangular.

Metapleurum (*Ascalaphus?*).

Myrmeleon. (Pl. LIV, fig. 9.) Although the meta- are not much shorter than the mesopleurites, the episternum (which is subdivided into an upper and lower sclerite) is smaller but nearly of the same shape as in the mesopleurites, but the coxæ are larger and broader in proportion. The supra-epimerite is very different, being as broad as long, not widening above, and it is solid, with no membranous area; while the infra-epimerite is a linear, antero-posterior ridge becoming triangular behind. The coxa is considerably larger than in the mesothorax. The trochantine is one-half smaller than that of the mesothorax.

Polystœchotes. (Pl. LVI, fig. 15.) The meta- are about one-third shorter than the mesopleurites. The episternum is as in the mesothorax, but the supra-sternite is fuller, more rounded next to the wings. The epimerum is divided into a supra- and infra-epimerite. The coxæ are more rounded and globose than in the mesothorax, while the trochantine is smaller and not so wide in proportion.

There is a great difference between the thorax of Polystœchotes and Myrmeleon, that of the latter being about twice as long as in the former; in both, however, the metathorax is shorter than the mesothorax.

Mantispa. The metapleurites are a little stouter and thicker than the mesopleurites, but have the same structure, though the coxæ are considerably shorter.

Sternum.

Ascalaphus?

Myrmeleon. (Pl. LIV, fig. 4.) The *prosternum* is rudimentary and membranous.

The *mesosternum* (Pl. LIV, fig. 5) is large and well developed, subcordate, deeply furrowed medially; about two-thirds as long as broad. There is no suture between it and the infra-episternite.

The *metasternum* (Pl. LIV, fig. 6) is much smaller than the mesosternum, but from lack of alcoholic specimens I can not here describe it.

Polystœchotes. The *prosternum* is rudimentary and membranous.

The *mesosternum* is triangular, cordate, one-half as long as wide in front; distinctly separated by suture from the infra-episternite, with a deep median furrow. The meta- as the mesosternite, but one-third as long.

Mantispa. The *prosternum* is very long and narrow, and is well developed. The *mesosternum* is large, broad, about one-third as long as broad; not distinctly separated by suture from the episternum; in this respect the metasternum is the same.

THE ABDOMEN.

Ascalaphus. (Pl. LVII, figs. 6, 7.) The abdomen is moderately long, spindle-shaped, with nine uromeres.

Myrmeleon. (Pl. LVII, figs. 8–10.) Very long and slender, more as in Odonata than other Neuroptera, being slender, cylindrical. There are seven well developed tergites; the 8th and 9th small, the 9th being as long as broad. The pleurites are broad, well developed, membranous; the spiracles distinct. Of the urosternites the first is obsolete, followed by six well-developed ones; the 7th well developed, oblong. The ♂ claspers are well developed, and are much as in Odonata.

Polystœchotes. (Pl. LVIII, figs. 2–4.) The abdomen is much shorter and thicker than in Myrmeleon. There are ten tergites; the 2nd subdivided into two subtergites, appearing as if two tergites; the 8th is one-third as long as the 7th; the 9th one-half as long as the 8th; the 10th is broader than long, the end being subconical. The pleurites are broad, membranous, six pairs of spiracles visible. There are seven urosternites, the first membranous and obsolete; the seventh longer than the sixth. No uropods; the cercopoda rudimentary.

Mantispa.—Broad and large, nine uromeres; the first tergite very short; ninth uromere very short, with very short uropoda?

Family PANORPIDÆ. Plate LX.

THE HEAD.

Panorpa.[158] (Pl. LX, figs. 1–3.) No true occiput. The epicranium is swollen on the vertex, which is as long as broad; there is a small ocellar area, and a small inter-antennal area. The front of the head is remarkably elongated, and is formed by the great development of the clypeus. The labrum? The genæ form an elongated tract, and the gula?

The submentum is a little longer than the mentum, while the lingua is short.

The antennæ are very long and many-jointed, as in moths, and the minute mandibles are situated at the end of the snout.

[158] On sending the specimen, after dissection, to Professor Hagen, he kindly informs me that it is "perhaps *P. debilis* Westw."

THE THORAX.

The *pronotum* (Pl. LX, fig. 4) is very small and short, with a deep transverse, impressed line; on the median line it is excavated in front and behind.

The *mesonotum* (Pl. LX, fig. 15) is without a præscutum; the scutum is large, about two-thirds as long as broad, and well-rounded in front. The scutellum is small, transversely narrow oblong. The post-scutellum is moderately long, interrupted by the median line.

The *metanotum* (Pl. LX, fig. 6) is much shorter than the mesonotum, but of the same general shape; the scutellum is also of the same general shape, but a little longer. The postscutellum is as in the mesonotum.

Pleurum.

The pleurites in this family are very long and narrow, the thorax being much compressed, its general shape approaching that of the Trichoptera and Lepidoptera.

The *propleurum* (Pl. LX, fig. 7) is rudimentary, the episterna and epimera being membranous.

The *mesopleurum* (Pl. LX, fig. 9) has the episternum undivided, and is moderately full in front. The epimerum is entire, narrow, a little shorter than the episternum, and not so broad. The coxa is rather slender; the trochantine long and narrow.

The *metapleurum* (Pl. LX, fig. 8) is as the mesopleurum, but the episternum andepimerum are decidedly shorter, and slightly broader in proportion. The coxæ are a little larger and thicker, while the trochantine is about the same.

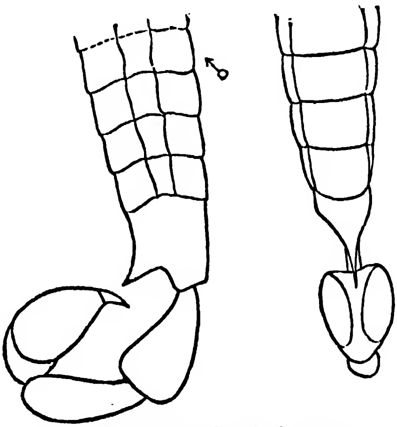
Sternum.

The *prosternum* is linear and rudimentary.

The *mesosternum* is short and broad, much as in Lepidoptera.

The *metasternum* is much smaller and less distinct than the mesosternum.

Finally, in the thorax as a whole, and in the form of the pleurites and sternites, we have a striking approximation to the Lepidoptera.



End of abdomen of male Panorpa, enlarged.

THE ABDOMEN.

There are ten uromeres; ten tergites, the first very short and transversely linear, the sixth to tenth narrow; there are seven urites, very narrow, as long as broad

The pleurites are membranous, broad, having the spiracles, of which there are eight pairs as usual, the last pair minute.

Fig. (in text) represents the end of the abdomen of the male of Panorpa.

Suborder 2. TRICHOPTERA. Plates LIX, figs. 1–5; LXI.

Limnephilus.[159] (Pl. LIX, figs. 1–5.) The head differs from all other *Phyloptera* in being constructed on a plan closely approaching that of the lepidoptera. It is short and high, and of the general proportions of the lepidopterous head. The vertex is as long as broad; the orbits wide. The clypeus is small, narrow, and situated high up; the labrum (Fig. 5) is small, narrow, elongate, subtriangular. (The exact differences from the Lepidopterous head are stated in the *American Naturalist*, Nov. 1871, vol. v, p. 711.) The mandibles are not present in Limnephilus, unless a slight pointed tubercle on each side of the lower part of the orbits (Fig. —, *md?*) may represent them. If so, they are consolidated with the epicranium, but I am inclined to think that these do not represent the mandibles at all, as rudimentary mandibles in the form of a movable tubercle are to be seen in Neuronia on each side of the base of the labrum.[160]

The maxillary palpi (Fig. 5) are long and slender, directed downward; the lobe on the side (Fig. 4, *lac.*) hangs down. It may perhaps be the homologue of the lacinia. The labial palpi are three-jointed (Fig. 5), while the mentum, palpiger, and an undivided rudimentary ligula are present.

The genæ are broad on the under side, while the gular region is narrow. The submentum is small and narrow; the mentum is trapezoidal, broadest in front.

THE THORAX.

Limnephilus. The *pronotum* (Pl. LXI, fig. 1) is much as in Lepidoptera, being divided into two transversely oval, narrow bosses by a deep median suture.

Mesonotum. (Fig. 2.) The patagia are thick, solid, rounded oval; longer than broad. The præscutum is obsolete.

The scutum is long and broad, with a prominent acute angle in the middle on each side. Surface with a deeply-impressed median line extending to the scutellum, and with a parallel, lateral impressed line. In general form there is a close approximation to the lepidopterous mesoscutum. It is deeply excavated behind for the reception of the scutellum, which is large, a little longer than broad, and subtriangular. The postscutellum is either wanting or it may be represented by a transverse ridge.

The *metanotum* (Fig. 3) is much as in the lepidopterous type. It is

[159] A common species, *L. pudicus* Hag.; identified by Dr. Hagen.

[160] In *Neuronia* they appear to be nearly of the same form as represented by Savigny in *Prhyganea grandis* (Mémoires sur les Animaux sans Vertèbres. Pl. I, Fig. 1.) In the pupa the mandibles are much larger.

a little more than one-half as long as the mesonotum. The præscutum is well marked, small, divided by the median line into two transversely oblong pieces, the broad end next to the median line.

The scutum is deeply cleft behind for the reception of the triangular scutellum, the anterior part of the latter nearly reaching the front edge of the scutum. It is narrower than long, the lateral sutures obscure. The postscutellum is wanting.

Pleurum.

Propleurum. (Fig. 4.) The episternum and epimerum are minute, rudimentary.

Mesopleurum. The meso- and metapleurites are high and short; the metapleurites a little shorter than the meso-; in this respect much as in Lepidoptera. The episternum is not subdivided; it is square oblong, nearly three times as long (deep) as wide. The epimerum is narrower, but of nearly the same shape, but excavated by the wing-membrane. The coxæ are long, narrow, conical, as long as the episternite; the trochantine one-half as wide as the coxa.

Metapleurum. (Fig. 6.) The episternum is much narrower than the mesepisternum, especially towards the wings, and the epimerum is nearly as wide as in the mesopleurum. The coxæ are fuller and thicker than those of the mesothorax, while the trochantine is much smaller, being one-half as thick and shorter than in the mesothorax.

Sternum.

The *prosternum* is short, but distinctly developed. The *mesosternum* is rather large, about two-thirds as long as broad, produced backward in the middle, with a subacute apex. The *metasternum* is obsolete, represented by a membranous area.

THE ABDOMEN.

The abdomen (Fig. 7–9) is long and slender, cylindrical, much as in the lower Lepidoptera. There are nine uromeres equally well developed, the eighth not much smaller than the preceding one; there are eight urites, the eighth very short. The pleural region is membranous, broad, but obsolete on the first and eighth uromeres, with a spiracle in the middle of each of the first eight pleuritic areas.

It will be observed that the Trichoptera occupy a much higher systematic position than any of the foregoing groups. This is seen in the loss of two terminal segments in the abdomen, in the small concentrated head, and the subspherical thorax.

The Trichoptera and Panorpidæ differ from the other Neuroptera in having the trochantine well developed and nearly as large or larger than the coxæ; in this respect and in the form of the legs they closely resemble the Lepidoptera. Brauer* has called attention to the fact that in the Trichoptera and Panorpidæ the coxæ are divided into two halves.

CHAPTER XII.

NOTE ON THE GEOGRAPHICAL DISTRIBUTION OF THE ROCKY MOUNTAIN LOCUST, ILLUSTRATED WITH A COLORED ZOÖ-GEOGRAPHICAL MAP OF NORTH AMERICA.

In the first report of the Commission (Chapter VI, p. 136) we traced the geographical limits of the Rocky Mountain locust, giving its eastern, northern, western, and its approximate southern limits; the latter being farther perfected and revised in Chapter VI of our second report, and in the colored map accompanying the report. On page 168 of our second report we also showed that the geographical limits of the western cricket (species of Anabrus) "are probably nearly or quite coextensive with those of the Rocky Mountain locust."

For the convenience of the general reader, as well as of naturalists, we have, with the permission of Dr. F. V. Hayden, reproduced, with certain minor corrections, a colored zoö-geographical map of North America. It was originally prepared to illustrate the distribution of certain fresh-water Crustacea (Phyllopods) and appears in the Twelfth Annual Report of the United States Geological Survey of the Territories. Upon sending a proof to Mr. J. A. Allen, who has paid special attention to the geographical distribution of the mammals and birds, he kindly returned it without corrections, stating that it agreed with his views as to the limits of the zoölogical regions and provinces. Another copy was sent to Prof. A. E. Verrill, who made some corrections in the eastern province around the Bay of Fundy, and a few less important changes. Hence it is believed that the map will represent with tolerable accuracy the zoölogical distribution not only of the insects in general, but of nearly all the other classes of the animal kingdom, excluding the marine forms.

The range of the Rocky Mountain locust is co-equal with the light-brown area, *i. e.*, the Central Province, except that it will probably not be found south of the isothermal of 72°. This province is also the home of the species of Anabrus or Western Crickets. These are among the most characteristic Orthopterous insects to be found in this province, although there are many other species not to be found elsewhere. On the other hand, the common red-legged locust, *Caloptenus femur-rubrum*, occurs all over the Boreal or Canadian, the Eastern, the Western (Pacific), as well as the Central Province, so that it ranges over the whole of North America south of the limit of trees and north of Mexico and Lower California. The distribution of a third species, *Caloptenus atlanis*, is nearly co-extensive with that of *C. femur-rubrum*, although it

is rare in the Central Province, it having only been found at Reno, on the western edge of the Central Province, and may possibly not be found associated with *C. femur-rubrum* in Utah.

The Central Province is characterized also by peculiar species of Myripods, of Arachnida, of Pseudoneuroptera, Coleoptera, Diptera, as well as Lepidoptera and Hymenoptera; such as are not found in the Eastern Province or the Pacific Province.

LETTERING OF THE ANATOMICAL PLATES.

The Head.

epic, epicranium.
cly, clypeus.
a. cly, ante-clypeus.
p. cly, post-clypeus.
lb, or *lbr*, labrum.
lb, labium.
gena, gena.
gula, gula.
ant, antenna.
e, eye.
oc, ocelli.
occ, occiput.
of, occipital foramen.
mx, 1st maxilla.
mx', 2d maxilla.
p, palpus.
c, cardo of maxilla.
st, *sti*, or *stip*, stipes of maxilla.
lac, lacinia of maxilla.
s. m., submentum.
m, mentum.
palpr, palpiger.
lig, ligula.
le, lamina exterior of ligula.
li, lamina interior of ligula.
md, mandible.

The Thorax.

PRO, prothorax.
MESO, mesothorax.
META, metathorax.
n, notum of prothorax.
n', notum of mesothorax.
n'', notum of metathorax.
p. sc, præscutum of prothorax.
sc, scutum of prothorax.
scl, scutellum of prothorax.
p. scl, post-scutellum of prothorax.
p. sc', *sc'*, *scl'*, *p. scl'* } the same sclerites of mesonotum.

The Thorax—Continued.

p. sc'', *sc''*, *scl''*, *p. scl''* } the same sclerites of metanotum.
st, sternum of prothorax.
st', sternum of mesothorax.
st'', sternum of metathorax.
epis, episternum of prothorax.
epis', episternum of mesothorax.
epis'', episternum of metathorax.
em, epimerum of prothorax.
em', epimerum of mesothorax.
em'', epimerum of metathorax.
te, trochantine of prothorax.
te', trochantine of mesothorax.
te'', trochantine of metathorax.
cx, coxa of prothorax.
cx', coxa of mesothorax.
cx'', coxa of metathorax.
tr, trochanter of prothorax.
tr', trochanter of mesothorax.
tr'', trochanter of metathorax.
s.-epis, &c., sur-episternum.
s.-em, &c., sur-epimerum.
i.-epis, &c., infra-episternum.
i.-em, &c., infra-epimerum.
pes, leg.
pt, patagia.
W¹, front wing.
W², hind wing.

The Abdomen.

A, abdomen.
c, cercopoda (cerci).
rh, rhabdite, or elements of the ovipositor, o clasper in the male.
ur, urosternite, or sternum of an uromere.*
tg, tergal sclerite or tergite.
pen, penis.
st, stigma or spiracle.
D, dorsal view.
L, lateral view.
V, ventral view.

* The author has sometimes inadvertently used the term *urite* instead of urosternite; Lacaze-Duthier's term urite is equivalent to our *uromere*.

The engraver has in some cases omitted the accents distinguishing the parts similarly lettered on the plates, but no confusion is likely to arise, upon careful examination of the figures and comparison with the text.

EXPLANATION OF PLATES.

PLATE I.

FIG. 1. *Leucania unipuncta:* *a*, male moth; *b*, abdomen of female—natural size: *c*, eye; *d*, antennal joints of male; *e*, do. of female—enlarged. (After Riley.)

FIG. 2. *Leucania unipuncta*, genitalia of male moth: *A*, end of body, denuded of hairs, showing the upper clasps protruding, and the natural position of the hidden organs by dotted lines; *B*, the organs extruded—enlarged. (After Riley.)

FIG. 3. *Leucania unipuncta*, ovipositor of female moth: *a*, end of abdomen, denuded and showing ovipositor atr est; *b*, same, with ovipositor fully extended; *e*, , retractile subjoints; *h*, eggs—enlarged: *g*, eggs, natural size. (After Riley.)

FIG. 4. *Leucania unipuncta:* pupa, natural size. (After Riley.)

FIG. 5. *Leucania unipuncta:* larva, natural size. (After Riley.)

FIG. 6. *Tachina flavicauda*, somewhat enlarged. (After Riley.)

FIG. 7. *Exorista leucaniæ*, somewhat enlarged. (After Walsh.)

FIG. 8. *Calosoma calidum:* *a*, larva; *b*, beetle—natural size. (After Riley.)

PLATE II.

FIG. 1. *Pasimachus elongatus*, natural size. (After Riley.)

FIG. 2. *Harpalus caliginosus*, natural size. (After Riley.)

FIG. 3. *Metapodius femoratus*, natural size. (After Glover.)

FIG. 4. *Calosoma scrutator*, natural size. (After Riley.)

FIG. 5. *Ophion purgatus*, natural size. (After Riley.)

FIG. 6. *Apanteles congregatus*, greatly enlarged. (After Walsh.)

FIG. 7. *Pezomachus minimus:* cocoons, natural size. (After Walsh.)

FIG. 8. *Mesochorus vitreus*, greatly enlarged. (After Walsh.)

FIG. 9. *Pezomachus minimus:* male and female, greatly enlarged. (After Walsh.)

PLATE III.

FIG. 1. *Paleacrita vernata:* *a*, full-grown larva, natural size; *b*, eggs, natural size and enlarged; *c*, side view of an enlarged segment of larva; *d*, dorsal view of same. (After Riley.)

FIG. 2. *Paleacrita vernata:* *a*, venation of fore-wing of male, natural size; *b*, do. of hind-wing; *c*, joint of male antenna, enlarged. (After Riley.)

FIG. 3. *Paleacrita vernata:* *a*, male moth, natural size; *b*, female do., natural size; *c*, joints of female antennæ, enlarged; *d*, joint of female abdomen, enlarged; *e*, ovipositor, enlarged. (After Riley.)

FIG. 4. *Paleacrita vernata:* female pupa, enlarged. (After Riley.)

FIG. 5. *Anisopteryx pometaria:* *a*, *b*, egg, side and top views, enlarged; *c*, *d*, side and dorsal views of an enlarged segment of larva; *e*, egg mass, natural size; *f*, larva, natural size; *g*, female pupa, natural size; *h*, dorsal view of anal tubercle of do., enlarged. (After Riley.)

FIG. 6. *Anisopteryx pometaria:* *a*, venation of fore-wing of male, natural size; *b*, do. of hind-wing; *c*, *d*, side and dorsal views of joints of male antennæ, enlarged. (After Riley.)

FIG. 7. *Anisopteryx pometaria:* *a*, male moth, natural size; *b*, female do.; *c*, joints of female antennæ, enlarged; *d*, joints of female abdomen, enlarged. (After Riley.)

FIG. 8. *Anisopteryx pometaria:* *a*, male pupa, enlarged; *b*, female do. (After Riley.)

EXPLANATION OF PLATES.

PLATE IV.

A healthy stalk of wheat on the left, the one on the right dwarfed and the lower leaves beginning to wither and turn yellow; the stem swollen at three places, near the ground, where the flaxseeds (*h*) are situated, between the stem and sheathing base of the leaf.

a, egg of the Hessian Fly (greatly enlarged, as are all the figures except *e* and *h*).

b, the larva, enlarged; the line by the side, in this and other figures, showing the natural length.

c, the flaxseed, puparium or pupa case.

d, the pupa or chrysalis.

e, the Hessian Fly, natural size, laying its eggs in the creases of the leaf.

f, female Hessian Fly, much enlarged.

g, male Hessian Fly, much enlarged.

h, flaxseed between the leaves and stalk.

i, chalcid or ichneumon parasite of the Hessian Fly: male, enlarged.

Figs. *b*, drawn by Mr. Riley; *d* and *f*, by Mr. Burgess; *a*, *g*, and *e*, *i*, by the author; copied on wood by L. Trouvelot.

PLATE V.

FIG. A. Side view of the female Hessian Fly, greatly enlarged: *a*, three joints taken from the middle of the antennæ of the female; *a'*, the three terminal female antennal joints; *a''*, the four basal, and *a'''*, the two terminal male antennal joints; *b*, a maxillary palpus; *c*, scales from the body and wings; *d*, *e*, side and vertical view of the last joint of the foot, showing the claws, and food-pad or pulvillus between them, and the scales on the joint. Drawn by Mr. E. Burgess.

FIG. B. Larva magnified, with the breast-bone in the 2d next ring to the head: *Ba*, the breast-bone highly magnified; *Bb*, head from beneath, enlarged; *Bc*, larval spiracle and its tubercle and trachea leading from the spiracle. B drawn by Mr. Riley; *Ba*, *Bb*, *Bc*, by Mr. Burgess.

FIG. C. Side and front view of the pupa or chrysalis. Drawn by Burgess. The abdomen of the side view of pupa is rather long, as the insect, when drawn, was just emerging from the semi-pupa stage, which it assumed December 1st.

FIG. D. The flaxseed, puparium, or pupa case. The line by the side of the complete figures denotes the natural length of the insect.

PLATE VI.

FIG. 1. *Chalcophora virginica?*: *ant*, antenna; *lbr*, labrum; *md*, mandible; *mx*, 1st maxilla; *mx'*, 2d maxilla (labium); *lp*, labial palpus; (this lettering the same for the other figures on Plates VI–XV; *l. pal*, labial palpus, enlarged; *s*, seta; *ch*, chitinous support.

FIG. 2. *Dicerca divaricata*, enlarged about twice: *b*, head and three thoracic segments, seen from beneath.

FIG. 3. Unknown larva, sweet gum tree, Houston, Texas: *v*, ventral view; p, prothorax; m, mesothorax; m', metathorax.

FIG. 5. Buprestid larva from under hemlock bark: *a*, natural size; *b*, head and prothorax from above; *c*, the same, drawn from below.

All the figures and details drawn by Dr. C. F. Gissler.

PLATE VII.

FIG. 1. *Elaphidion parallelum*: *a*, from above; *b*, from beneath; *f*, ligula-like process situated behind and not between the labial palpi.

FIG. 2. Unknown longicorn larva under bark of pin oak, Houston, Tex.; *v*, under side.

FIG. 3. *Criocephalus agrestis*: pupa, dorsal view, enlarged 2 times.

FIG. 3*a*. *Criocephalus agrestis*: pupa, ventral view.

FIG. 4. *Melanophila*, under bark of spruce: *v s*, under side of prothoracic disc. (See, also, Pl. XII, Fig. 1.)

Gissler del.

PLATE VIII.

FIG. 1. Unknown longicorn larva, from under bark of pitch pine, Atlanta, Ga. × 2 times: *va*, head and five succeeding segments, from beneath; *vb*, 4th abdominal segment, from beneath; *vc*, 7th abdominal segment, from beneath; *lat*, lateral view of head and four succeeding segments, with prothoracic and 1st abdominal spiracle; *md*, two views of the mandibles. Length of larva 37^{mm}; width of prothoracic segment 10^{mm}; length of same 4.5^{mm}; width of mesothoracic 9.5^{mm}; of 1st abdominal segment 9^{mm}. Average width 8.1^{mm}.

FIG. 2. *Saperda tridentata*. Length 18^{mm}; width of prothoracic segment 5^{mm}; *v*, under side of head and five succeeding segments; *lat*, lateral views of the same; *md*, three views of the mandibles.

All the figures enlarged, and drawn by C. F. Gissler, under the author's directions.

EXPLANATION OF PLATES.

PLATE IX.

FIG. 1. *Asemum mœstum:* *v*, under side of thoracic segments, showing the three pairs of legs; with the three succeeding segments; *lat*, lateral view of head, three thoracic and 1st abdominal segments.

FIG. 2. Longicorn larva, under bark of oak, Atlanta, Ga. Length 18mm; width of prothoracic segment 5.2mm: ventral view same as dorsal. Body narrowest in the middle; prothoracic segment short and very broad; the elevated areas or callosities dark and prominent; antennæ long, 4-jointed; 2d joint much shorter than the 1st; 4th joint minute, half as long as the 3d is thick; labrum rather narrow; 3 pairs of short, acute thoracic feet.

FIG. 3. Longicorn larva, under bark of *Pinus strobus*, May 26. Length, 14mm; *x*, two fleshy processes, with horny tips, on the median area of tergum of 9th abdominal segment.

FIG. 4. Longicorn larva, on sweet gum tree (log), Houston, Tex. Length, 10mm; *e*, end of body, showing a curved spine on the dorsal side of the 9th abdominal segment, and on each side of the latter a fleshy process with a terminal bristle.

C. F. Gissler del.

PLATE X.

FIG. 1. *Orthosoma brunneum:* *v*, under side of three thoracic (with feet) and first two abdominal segments; *lat*, side of head and four succeeding segments, showing the feet; *lbr*, labrum and clypeus with front edge of epicranium.

FIG. 2. Longicorn larva from sycamore: *v*, under side of the three thoracic and four basal abdominal segments.

FIG. 3. Pupa of a longicorn beetle (*Oncideres?*) found under bark of pin oak, April. Length, 18mm.; width of prothorax, 4.4mm.

Gissler del.

PLATE XI.

FIG. 1. *Rhagium lineatum*, dorsal view: *v*, under side of head and pro- and mesothoracic segments; *vms*, one of the middle ventral segments, magnified six times; *ml*, mala of the maxilla.

FIG. 2. *Rhagium lineatum*, vertex, top of head: *ep*, front of epicranium; *oc*, eyes; *cly*, clypeus, membraneous on the edge; *ch*, two chitinous supports of (*lbr*) the labrum; *ml*, mala or single lobe of the maxilla; *md*, mandible.

FIG. 3. Longicorn larva from oak log, Providence, May 20. *v*, under side of thoracic segments, showing the legs; *ml*, mala of maxilla; *mx'*, labium; *sm*, submentum; *m*, mentum; *lig*, ligula.

FIG. 4. *Saperda* larva from willow.

Gissler del.

PLATE XII.

FIG. 1. *Melanophila:* *lbr*, labrum and front of head, with the antennæ (*ant*); *s'*, prothoracic stigma; *s*, one of the abdominal stigmata.

FIG. 2. *Xylotrechus colonus:* *lat.*, side view of head and 6 succeeding segments.

FIG. 2*a*. *Xylotrechus colonus*, mouth parts: lettering as in other figures.

FIG. 3. *Xylotrechus colonus?*, under bark of black birch, Providence, May 20.

FIG. 4. Details of mouth-parts of *Saperda* larva from willow trunk, represented at Plate XI, Fig. 4.

FIG. 5. Longicorn larva found under hemlock bark, The Glen, N. H., July 22.

FIG. 6. Longicorn larva found under bark of hemlock, Bath, Me., July 30. Enlarged; *md,o*, outer; *md,i*, inner side of the mandible.

All the figures enlarged. Gissler del.

PLATE XIII.

FIG. 1. Unknown larva from log of sweet gum tree, Houston, Tex.

FIG. 2. Pupa, *h*. Glen, N. H., July 22.

FIG. 3. *Xestobium affine*, mouth-parts of larva. (See Bulletin 7, U. S. Entomological Commission, p. 109.)

FIG. 4. *Hylurgops pinifex*, and mouth-parts. (See Bulletin 7, U. S. Entomological Commission, pp. 177, 232.)

FIG. 5. *Pissodes strobi*, larva (9mm long) and mouth-parts.

FIG. 6. *Pissodes strobi*, pupa: *hd*, front of head and beak, with antennæ; *ab*, end of abdomen, with the fleshy lateral processes.

Gissler del.

EXPLANATION OF PLATES.

PLATE XIV.

FIG. 1. *Xyloteres bivittatus*, larva.
FIG. 1ᵃ. *Xyloteres bivittatus*, pupa.
FIG. 2. *Xyleborus cœlatus*, larva.
FIG. 2ᵃ. *Xyleborus cœlatus*, mandible.
FIG. 3. *Xyleborus cœlatus*, pupa, dorsal view.
FIG. 3ᵃ. *Xyleborus cœlatus*, pupa, end of abdomen, much enlarged.
FIG. 4. *Crypturgus atomus*, larva.
FIG. 5. *Crypturgus atomus*, larva: *md*, mandible; *mx'*, labium.
FIG. 5ᵃ. *Crypturgus atomus*, larva: *md*, mandible.
FIG. 5ᵇ. *Crypturgus atomus*, maxilla.
FIG. 5ᶜ. *Crypturgus atomus*, pupa, end of body.
FIG. 6. Chalcid parasite of *X. cœlatus* or *Crypturgus atomus*: *w*, wing; *ant*, antenna.
FIG. 6ᵃ. Chalcid parasite, larva, 2ᵐᵐ in length.
FIG. 7. Unknown larva, 4ᵐᵐ in length, under bark of pine, probably preying on lignivorous scolytid larvæ. Maine.
FIG. 8. Pupa of longicorn larva, under bark of sycamore tree, Brooklyn, N. Y.: *p*, end of abdomen seen from above.
FIG. 9. *Hylurgops pinifex*, pupa.

All the figures enlarged. Gissler del.

PLATE XV.

FIG. 1. *Selandria* larva, common on *Carya porcina*, with details of mouth parts: *leg*, leg; *mx*, maxilla; *gal*, galea (*=mala exterior*); *lac*, lacinia (*=mala interior*). Other letters as heretofore.
FIG. 2. Deltoid larva (before last molt), on *Carya porcina* and sometimes on oak, May 25, June 20th: n. s., larva of natural size, head downward; p³, third leg; *mx* and *mx'*, maxilla and labium (the dotted line ends on the maxillary lobe or *mala*); *sp*, spinneret at end of lingua; *p*, maxillary palpus; *cly*, clypeus; *lbr*, labrum; *l*, fleshy lobe.
FIG. 3. Unknown larva, common under bark, preying on destructive scolytid beetles.
FIG. 4. Unknown larva, yellowish, under bark; 8ᵐᵐ in length: *ab*, end of abdomen.
FIG. 5. Carabid larva, under bark of pine; length, 4ᵐᵐ.

All the figures enlarged. Gissler del.

PLATE XVI.

EMBRYOLOGY OF CALOPTENUS SPRETUS.

FIG. 1. Dorsal view of embryo, showing the stomodæum (*st*) and proctodæum (*pr*), with the nervous system: *br*, brain; *g. op*, optic ganglion; *ng*, ganglia; the salivary glands (*sal*) and the two pairs of thoracic spiracles and eight pairs of abdominal spiracles 1–8, and indications of the tracheæ (*tr' tr''*), perhaps in part the fat bodies; *am*, amnion.
FIG. 2. Nucleated cells of the skin of the 2d segment: × ½ A.
FIG. 3. Nucleated cells of the amnion: × ½ A.
FIG. 4. Portion of the eye: *c*, cones; *rod*, rods; *ret*, retina.
FIG. 5. Vertical view of the head, with the outline of the brain and the rudiments of the three ocelli.

Author del.

PLATE XVII.

EMBRYOLOGY OF CALOPTENUS SPRETUS.

FIG. 1. Embryo when first observed in the egg. I—IV, antennæ and mouth-parts; V—VII, three pairs of legs.
FIG. 1ᵃ. The same, enlarged. Amnion not drawn: *occ*, occiput.
FIG. 2. More advanced embryo.
FIG. 2ᵃ. Four abdominal ganglia.
FIG. 3. Embryo, showing the three lobes of the maxillæ, and the two lobes of the labium.
FIG. 4. More advanced embryo, showing the stigmata, the fat body, and the anus.
FIG. 5. Some of the free cells among the yolk cells.

Author del.

PLATE XVIII.

EMBRYOLOGY OF CALOPTENUS SPRETUS.

FIG. 1. Advanced embryo seen from beneath, showing the brain and subœsophageal ganglia and the two succeeding pairs (1–3); also the three lobes of the 1st maxillæ, and the two lobes of the 2d maxillæ.
FIG. 2. Embryo in act of turning: *ng*, anglia; *am*, amnion.
FIG. 3. Head from above: *oc*, anterior ocellus; *ocn*, ocellar nerve; *st*, stomodæum.
FIG. 4. One of the procephalic lobes, with the antenna attached; showing the eye, the optic ganglion, and the antenna.

Author del.

EXPLANATION OF PLATES.

PLATE XIX.

EMBRYOLOGY OF CALOPTENUS SPRETUS.

FIG. 1. Section (No. 1) of head of embryo, showing the brain and eyes: *f*, white or fibrous matter; *gc*, outer layer of ganglion-cells enveloping the white or fibrous matter.

FIG. 2. Section (No. 6) through suboesophageal ganglion, *sg*, and stomach (*stm*); *y*, yolk.

FIG. 3. Section (No. 8) through end of oesophagus (*oe*), also passing through the six stomachic cœca (*cœc*) and ganglion (*g*) and a pair of the legs (*leg*).

FIG. 4. Section (No. 11) through the stomach and cœca and ganglion.

FIG. 5. Portion of the serous layer: × ½B.

FIG. 6. Section of a trachea.

Author del.

PLATE XX.

EMBRYOLOGY OF CALOPTENUS ATLANIS.

FIG. 1. Embryo 10 days old. Section No. 35 from end (the sections numbered from the end of abdomen forwards), through the brain (*br*) and optic ganglion (*op. g*) and eyes.

FIG. 2. Amœboid cells of the protoplasmic network enclosing the yolk-balls: *n*, nucleus.

FIG. 3. Section No. 26 through the same embryo, passing through the heart (*ht*), the ganglion (*g*), the trachea (*tr*), and the legs (*l*).

FIG. 3ª. Section of the main trachea, enlarged.

FIG. 3ᵇ. Section through the chorion (*ch*), and the serous membrane (*s. m*), with the nucleus (*n*).

FIG. 4. Section 27 through the heart.

FIG. 5. Section 20, showing the protoplasmic network in the yolk.

Author del.

PLATE XXI.

EMBRYOLOGY OF CALOPTENUS ATLANIS.

FIG. 5*a*. Section through the yolk: *n*, nuclei staining red with carmine; *am*, protoplasmic threads arising from the amnion.

FIG. 6. Section 7 through the same embryo as on *Pl. XX*: *gl*, *inner or glandular layer of intestine*; *fl*, *outer or muscular (faser)* layer; *ut*, *urinary tubes*; *ut′*, the same seen in section.

FIG. 7. Section No. 5, through the intestine; *do?*, dorsal organ?; *bl*, blastoderm.

FIG. 8. Section No. 4 from end of body, through the proctodæum (*pr*).

FIG. 8*a*. Same section as 8, showing section of the proctodæum, *pr*: *fl*, faser layer; *gl*, glandular layer of the proctodæum; *am*, amnion; *bl.*, blastoderm; much enlarged.

FIG. 9. Section No. 3, passing through the edge of the proctodæum: *ch*, chorion; *do*, dorsal organ, × ½ A.

Author del.

PLATE XXII.

EMBRYOLOGY OF XYLEBORUS AND HYLURGOPS.

FIG. 1. ***Xyleborus cœlatus***, embryo 24 hours after fertilization: *pb*, primitive band; *ser*, serous membrane: *pl*, procephalic lobe.

FIG. 2. ***Xyleborus cœlatus***: a^1–a^7, arthromeres of head and thorax; 1–8, first eight abdominal arthromeres; *th*, protoplasmic threads connecting cells of amnion with the serous membrane.

FIG. 3. ***Xyleborus cœlatus***, dorsal view of embryo: *pl*, procephalic lobes.

FIG. 4. ***Hylurgops pinifex***, embryo. Gissler del.

FIG. 5. ***Xyleborus cœlatus***, embryo about four days old, showing spiracles (sp^1–sp^3) in each thoracic arthromere, or eleven pairs of spiracles in all: *tr*, tracheæ? 1–4, antennæ and mouth parts.

FIG. 6. ***Xyleborus cœlatus***, head of embryo, seen from beneath.

FIG. 7. ***Hylurgops pinifex***, advanced embryo. Gissler del.

FIG. 8. ***Hylurgops pinifex***, larva 1.5ᵐᵐ long: *st′*, prothoracic stigma; *st*, stomach; *i*, intestine; *r*, rectum.

FIG. 9. ***Hylurgops pinifex***: *a*, three larvæ immediately after hatching; *b*, one, enlarged. Gissler del.

FIG. 10. ***Hylurgops pinifex***, end of body of larva 1.5ᵐᵐ in length: *a*, anus; *as*, anal sucker. Gissler del.

Figs. 1–3, 5 drawn by the author.

EXPLANATION OF PLATES.

PLATE XXIII.

FIG. 1. *Forficula tæniata* Dohrn, head, upper side.

FIG. 2. *Forficula tæniata* Dohrn, head, under side, *lac*, lacinia; *le*, lamina exterior of ligula.

FIG. 3. *Forficula tæniata* Dohrn, head, side view.

FIG. 4. *Forficula tæniata* Dohrn, mandible.

FIG. 5. *Forficula tæniata* Dohrn, maxilla.

FIG. 6. *Forficula tæniata* Dohrn, 2d maxilla (labium): *l*, ligula; *le*, lamina exterior; *p*, palpus.

FIG. 7. *Forficula tæniata* Dohrn, pronotum, dorsal view.

FIG. 8. *Forficula tæniata* Dohrn, meso- and metanotum.

FIG. 9. *Forficula tæniata* Dohrn, pro-, meso-, and meta-thorax, sternal view.

FIGS. 10-12. *Forficula* larva, pro-, meso-, and metanotum: *not*, notum; *pst*, præ-sternum; *st*, sternum.

All enlarged. Drawn by C. F. Gissler, under author's direction.

PLATE XXIV.

FIG. 1. *Forficula*, American species. Propleurum: *not*, notum.

FIG. 2. *Forficula*, American species. Mesopleurum: *not*, notum.

FIG. 3. *Forficula*, American species. Metapleurum: *not*, notum.

FIG. 4. *Forficula*, American species. Prosternum.

FIG. 5. *Forficula*, American species. Mesosternum.

FIG. 6. *Forficula*, American species. Metasternum.

FIG. 7. *Forficula*, American species. Abdomen, lateral view: *c*, cercopoda.

FIG. 8. *Forficula*, American species. Abdomen, dorsal view: *c*, cercopoda.

FIG. 9. *Forficula*, American species. Abdomen, ventral view: *c*, cercopoda.

All the figures enlarged. Gissler del., under the author's directions.

(Pls. XXV-XXXII drawn by J. S. Kingsley.)

PLATE XXV.

FIGS. 1-14. Heads (front view) of typical Orthoptera.

PLATE XXVI.

FIGS. 1-13. Heads (top view) of typical Orthoptera.

FIGS. 14-27. Heads (side view) of typical Orthoptera.

PLATE XXVII.

FIGS. 1-14. Labium of typical Orthoptera.

PLATE XXVIII.

FIGS. 1-12. Maxilla (left) of typical Orthoptera.

FIGS. 13-20. Prothorax (tergal view) of typical Orthoptera.

PLATE XXIX.

FIGS. 1-13. Prothorax (lateral view) of typical Orthoptera.

FIGS. 14-16. Prothorax (tergal view) of typical Orthopera.

PLATE XXX.

FIGS. 1-13. Meso- and metathorax (tergal view) of typical Orthoptera.

PLATE XXXI.

FIGS. 1-12. Meso- and metapleura of typical Orthoptera.

FIGS. 13-21. Prosternum of typical Orthoptera.

PLATE XXXII.

FIGS. 1-13. Meso- and metasternum of typical Orthoptera.

PLATE XXXIII.

FIGS. 1-3. *Mantis carolina*. Prothorax.

FIGS. 4, 5. *Mantis carolina*. Meso- and metanotum.

FIG. 6. *Prisopus* (Brazil). Propleurum.

FIG. 7. *Prisopus* (Brazil). Meso- and metapleurum.

FIG. 8. *Prisopus* (Brazil). Prosternum.

FIG. 9. *Prisopus* (Brazil). Meso- and metasternum.

Gissler del.

EXPLANATION OF PLATES.

PLATE XXXIV.

FIGS. 1–8, 10, 11. Abdomen (tergal view) of typical female Orthoptera.

FIG. 9. Abdomen (tergal view) of male *Diaphero-mera*.

PLATE XXXV.

FIGS. 1–9. Abdomen (end, tergal view) of typical female Orthoptera.

FIGS. 10–16. Abdomen (end, tergal view) of typical male Orthoptera.

PLATE XXXVI.

FIGS. 1–9. Abdomen, side view, of typical female Orthoptera.

PLATE XXXVII.

FIGS. 1–6. End of abdomen, side view, of typical Orthoptera.

PLATE XXXVIII.

FIGS. 7–16. End of abdomen, side view, of typical female Orthoptera.

(Plates XXXIV–XXXVIII drawn by J. S. Kingsley.)

PLATE XXXIX.

FIG. 1. *Termopsis angusticollis*, head, from beneath: *x*, hypopharyngeal chitinous support. (Gissler).

FIG. 2. *Termopsis angusticollis*, head, from above.

FIG. 3. *Termopsis angusticollis*, head, from side; the clypeus is shaded.

FIG. 4. *Termes flavipes*, head, from above: *v*, epicranial v-shaped suture.

FIG. 5. *Termes flavipes*, head, from side.

FIG. 6. *Psocus* sp., head, from above: *v*, v-shaped suture.

FIG. 7. *Psocus* sp., head, from side.

FIG. 8. *Pteronarcys californica*, head, drawn from the side.

FIGS. 1–5 drawn by C. F. Gissler; 6, 7, 8, by William W. Griffin: all magnified.

PLATE XL.

FIG. 1. *Pteronarcys californica*, head, upper view.

FIG. 2. *Pteronarcys californica*, head, under view.

FIG. 3. *Termopsis angusticollis*, 1st maxilla: *c*, cardo.

FIG. 4. *Termes flavipes*, 1st maxilla.

FIG. 5. *Pteronarcys californica*, 1st maxilla.

FIG. 6. *Pteronarcys californica*, 2d maxilla (labium).

FIG. 7. *Pteronarcys californica*, mandible.

FIG. 8. *Termopsis angusticollis*, labrum and part of clypeus.

FIG. 9. *Termes flavipes*, labrum.

Figs. 1, 2, 5–7 drawn by William W. Griffin; 3, 4, 8, 9, by Gissler: all magnified.

PLATE XLI.

FIG. 1. *Termes flavipes*, head seen from beneath: *mx*, maxilla; *palpr*, palpiger; *li*, lamina interior; *le*, lamina exterior; *p*, labial palpus.

FIG. 2. *Termes flavipes*, 2d maxilla (labium), seen from beneath.

FIG. 3. *Termopsis angusticollis*, 2d maxilla (labium).

FIG. 4. *Termes flavipes*, mandible, external view.

FIG. 5. *Termes flavipes*, mandible, internal view.

FIG. 6. *Termopsis angusticollis*, mandible, from within.

FIG. 7. *Termopsis angusticollis*, mandible, from without.

FIG. 8. *Termopsis angusticollis*, mandible, from without.

FIG. 9. *Termopsis angusticollis*, mandible, from within.

FIG. 10. *Termopsis angusticollis*, part seen beneath the labial palpi.

All enlarged. Gissler del.

PLATE XLII.

FIG. 1. *Termes flavipes*. Pronotum.

FIG. 2. *Termes flavipes*. Mesonotum.

FIG. 3. *Termes flavipes*. Metanotum.

FIG. 4. *Termes flavipes*. Propleurum.

FIG. 5. *Termes flavipes*. Mesopleurum.

FIG. 6. *Termes flavipes*. Metapleurum.

FIG. 7. *Termes flavipes*. Prothorax, sternal view.

FIG. 8. *Termes flavipes*. Mesothorax, sternal view.

FIG. 9. *Termes flavipes*. Metathorax, sternal view.

FIG. 10. *Termes flavipes*. Abdomen, tergal view: 1–10, the ten tergites; *c*, cercopoda.

FIG. 11. *Termes flavipes*. Abdomen, ventral view.

FIG. 12. *Termes flavipes*. Abdomen, lateral view, showing the 10 tergites and 9 urites.

All magnified. Gissler del., under author's direction.

EXPLANATION OF PLATES.

PLATE XLIII.

FIG. 1. *Termopsis angusticollis*, pronotum.
FIG. 2. *Termopsis angusticollis*, mesonotum: w^1, 1st pair of wings.
FIG. 3. *Termopsis angusticollis*, metanotum: w^2, 2d pair of wings.
FIG. 4. *Termopsis angusticollis*, propleurum.
FIG. 5. *Termopsis angusticollis*, mesopleurum.
FIG. 6. *Termopsis angusticollis*, metapleurum.
FIG. 7. *Termopsis angusticollis*, prothorax, sternal view: *pst*, præsternum; *not*, notum.
FIG. 8. *Termopsis angusticollis*, mesothorax, sternal view.
FIG. 9. *Termopsis angusticollis*, metathorax, sternal view.
FIG. 10. *Psocus novæ-scotiæ*, meso- and metathorax (notum), dorsal view: w^1, w^2, wings.
FIG. 11. *Psocus novæ-scotiæ*, metanotum, seen more from behind.
FIG. 12. *Psocus novæ-scotiæ*, meso- and metapleura.
FIG. 13. *Psocus novæ-scotiæ*, mesothorax, seen from in front.
FIG. 14. *Psocus novæ-scotiæ*, mesoscutellum.

NOTE.—Plates XXXVII and XXXVIII have been combined so that the explanations apply to Plate XXXVII, and there is no Plate XXXVIII.

FIG. 3. *Pteronarcys californica*, metapleurum.
FIG. 4. *Pteronarcys californica*, prosternum
FIG. 5. *Pteronarcys californica*, mesosternum.
FIG. 6. *Pteronarcys californica*, metasternum.
view: *rh*, rhabdites.
FIG. 9. *Pteronarcys californica*, abdomen, lateral view: *br*, branchiæ or gills; *sp*, spiracles.

William W. Griffin del., under author's direction. All magnified.

PLATE XLV.

FIG. 1. *Ephemera* (*Leptophlebia*) *cupida?* Head and thorax, dorsal view: *pro-n*, pronotum; w^1, w^2, 1st and 2d pair of wings; 1, first abdominal segment.
FIG. 2. *Ephemera* (*Leptophlebia*) *cupida?* Head seen from beneath: *lb*, labium; *lp*, labial palpi; *mx*, maxilla; *st*, prosternum.
FIG. 3. *Ephemera* (*Leptophlebia*) *cupida?* Head seen from above.
FIG. 4. *Ephemera* (*Leptophlebia*) *cupida?* Head and prothorax, seen laterally.
FIG. 5. *Ephemera* (*Leptophlebia*) *cupida?* Meso- and meta-sternum: *sp*, spiracle.
FIG. 6. *Ephemera* sp., larva, head seen from in front: *md*, mandibles.
FIG. 7. *Ephemera* sp., larva, head seen from the side, the occipital region not drawn.
FIG. 8. *Ephemera*, pupa, head seen from in front.
FIG. 9. *Ephemera*, imago, head seen from above.
FIG. 10. *Ephemera*, imago, head seen from above, different view, more in front.

Figs. 1–5 drawn by Dr. C. F. Gissler; 6–10, author del.

PLATE XLVI.

FIG. 1. *Ephemera* (*Leptophlebia*) *cupida?* Male, much enlarged to show the structure of the notum and abdomen: *c*, cercopoda; *rh*, outer 3-jointed claspers or rhabdites; rh^1, inner pair of 3-jointed rhabdites.
FIG. 2. *Ephemera* (*Leptophlebia*) *cupida?* Side view of thorax: the lettering as in other plates.
FIG. 3. *Ephemera* (*Leptophlebia*) *cupida?* Side view of propleurum, with side view of notum.
FIG. 4. *Ephemera* (*Leptophlebia*) *cupida?* Abdomen, ventral view, showing the 9 urosternites.
FIG. 5. *Ephemera* (*Leptophlebia*) *cupida?* Abdomen, lateral view.

All the figures enlarged. Gissler del.

PLATE XLVII.

FIG. 1. *Æschna heros*, head, front view: *cl. p*, post-, *cl. a*, ante-clypeus.
FIG. 2. *Æschna heros*, head, lateral view.
FIG. 3. *Æschna heros*, head, under view.
FIG. 4. *Agrion verticale?*, head, vertical view.
FIG. 5. *Agrion verticale?*, head, under view.
FIG. 6. *Agrion verticale?*, head, lateral view.
FIG. 7. *Æschna heros*, labium: 1, 2, 1st and 2d joint of labial palpus; *le*, lamina exterior of ligula; *li*, lamina interior.
FIG. 8. *Æschna heros*, maxilla.
FIG. 9. *Æschna heros*, mandible.
FIG. 10. *Agrion verticale?*, pronotum.
FIG. 11. *Agrion verticale?*, dorsal portion of meso- and metathorax, showing the great development of the episterna (*epis'*) and epimera (*em'*).
FIG. 12. *Calopteryx maculata*, pronotum.
FIG. 13. *Calopteryx maculata*, same as in Fig. 11.

All the parts enlarged; drawn by William W. Griffin, under author's direction.

EXPLANATION OF PLATES.

PLATE XLVIII.

FIG. 1. *Æschna heros*, meso- and metapleurum, and two abdominal arthromeres.
FIG. 2. *Æschna heros*, pronotum.
FIG. 3. *Æschna heros*, mesonotum.
FIG. 4. *Æschna heros*, metanotum.
FIG. 5. *Calopteryx maculata*, meso- and metanotum.
FIG. 6. *Calopteryx maculata*, pleurum of entire thorax.
FIG. 7. *Agrion verticale?*, propleurum.
FIG. 8. *Agrion verticale?*, pleurum of entire thorax, lettering as in Fig. 6: 1, 2, uromeres.

Figs. 1, 5, and 6 drawn by C. F. Gissler; figs. 3, 4, and 7, by William W. Griffin, under author's direction. Objects all enlarged.

PLATE XLIX.

FIG. 1. *Æschna heros*, abdomen, dorsal view, showing the 11 tergites: *c*, cercopoda. (1–11).
FIG. 2. *Æschna heros*, abdomen, lateral view.
FIG. 3. *Æschna heros*, abdomen, ventral view, the 11th tergite (11) seen from beneath: *t*, testes; *ur*, urosternites.

William W. Griffin del.

PLATE L.

FIG. 1. *Æschna heros*, end of female abdomen, showing the ovipositor: *ur*, urosternite; *or*, outer; *mr*, middle; *ir*, inner rhabdites or elements of the ovipositor; 11, 11th tergite; *c*, cercopoda; 1 and 2, uromeres, showing the external genital armature, the tergites widely separated.
FIG. 2. *Æschna heros*, male: *pen*, penis; *tg*, tergite; *cl*, clasper (basirhabdite); *ur*, urosternite of 2d uromere.
FIG. 3. *Æschna heros*, the same, with the tergites closed.
FIG. 4. *Agrion verticale?*, abdomen of male, side view: *pen*, penis; *c*, cercopoda.
FIG. 5. *Agrion verticale?*, abdomen of male, ventral view: *ur*, urosternite.
FIG. 6. *Agrion verticale?*, abdomen of male, end: 11, 11th tergite.

William W. Griffin del. All the parts enlarged.

PLATE LI.

FIG. 1. *Myrmeleon diversum*, head from above.
FIG. 2. *Myrmeleon diversum*, head from beneath: *of*, occipital foramen.
FIG. 3. *Ascalaphus longicornis?*, head from above; and beneath; *epic*, epicranium.
FIG. 4. *Ascalaphus*, head from beneath.
FIG. 5. *Raphidia oblita*, head from above.
FIG. 6. *Raphidia oblita*, head from beneath.
FIG. 7. *Raphidia oblita*, head from side; *oc*, occiput.
FIG. 8. *Polystœchotes nebulosus*, head from above.
FIG. 9. *Polystœchotes nebulosus*, head from beneath.
FIG. 10. *Polystœchotes nebulosus*, head from side.

William W. Griffin del. All the figures drawn enlarged.

PLATE LII.

FIG. 1. *Corydalus cornutus*, head seen from beneath.
FIG. 2. *Corydalus cornutus*, head seen from above: *a. cly*, ante-clypeus; *p. cly*, post-clypeus.
FIG. 3. *Corydalus cornutus*, head seen sidewise.
FIG. 4. *Mantispa brunnea*, head seen sidewise.
FIG. 5. *Mantispa brunnea*, head seen from above.
FIG. 6. *Mantispa brunnea*, head seen from beneath.

All enlarged. Gissler del., under author's direction.

PLATE LIII.

FIG. 1. *Mantispa brunnea*, 1st maxilla: *c*, cardo; *st*, stipes; *l*, lacinia; *g*, gala; *p*, palpus.
FIG. 2. *Ascalaphus longicornis*. 1st maxilla.
FIG. 3. *Myrmeleon diversum*, 1st maxilla.
FIG. 4. *Corydalus cornutus*, 1st maxilla.
FIG. 5. *Mantispa brunnea*, 2d maxilla (labium).
FIG. 6. *Ascalaphus longicornis?*, 2d maxilla (labium).
FIG. 7. *Raphidia oblita*, 2d maxilla (labium).
FIG. 8. *Myrmeleon diversum*, 2d maxilla (labium).
FIG. 9. *Corydalus cornutus*, 2d maxilla (labium).

All enlarged. William W. Griffin del., under author's direction.

EXPLANATION OF PLATES.

PLATE LIV.

FIG. 1. *Myrmeleon diversum*, pronotum.
FIG. 2. *Myrmeleon diversum*, mesonotum.
FIG. 3. *Myrmeleon diversum*, metanotum.
FIG. 4. *Myrmeleon diversum*, prosternum.
FIG. 5. *Myrmeleon diversum*, mesosternum.
FIG. 6. *Myrmeleon diversum*, metasternum.
FIG. 7. *Myrmeleon diversum*, propleurum.
FIG. 8. *Myrmeleon diversum*, mesopleurum.
FIG. 9. *Myrmeleon diversum*, metapleurum.
FIG. 10. *Raphidia oblita*, pronotum.
FIG. 11. *Raphidia oblita*, mesonotum.
FIG. 12. *Raphidia oblita*, metanotum.
FIG. 13. *Raphidia oblita*, propleurum.
FIG. 14. *Raphidia oblita*, mesopleurum.
FIG. 15. *Raphidia oblita*, metapleurum.
FIG. 16. *Raphidia oblita*, prosternum.
FIG. 17. *Raphidia oblita*, mesosternum.
FIG. 18. *Raphidia oblita*, metasternum.

All magnified. William W. Griffin del., under author's direction.

PLATE LV.

FIG. 1. *Mantispa brunnea*, pronotum.
FIG. 2. *Mantispa brunnea*, mesonotum.
FIG. 3. *Mantispa brunnea*, metanotum.
FIG. 4. *Mantispa brunnea*, prosternum.
FIG. 5. *Mantispa brunnea*, mesosternum.
FIG. 6. *Mantispa brunnea*, metasternum.
FIG. 7. *Mantispa brunnea*, propleurum.
FIG. 8. *Mantispa brunnea*, mesopleurum.
FIG. 9. *Mantispa brunnea*, metapleurum.

All enlarged. William W. Griffin del.

PLATE LVI.

FIG. 1. *Ascalaphus longicornis?*, pronotum.
FIG. 2. *Ascalaphus longicornis?*, mesonotum.
FIG. 3. *Ascalaphus longicornis?*, metanotum.
FIG. 4. *Ascalaphus longicornis?*, mesopleurum.
FIG. 5. *Ascalaphus longicornis?*, metapleurum.
FIG. 6. *Ascalaphus longicornis?*, mesosternum.
FIG. 7. *Ascalaphus longicornis?*, metasternum.
FIG. 8. *Polystœchotes nebulosus*, pronotum.
FIG. 9. *Polystœchotes nebulosus*, mesonotum: w^1, 1st wings.
FIG. 10. *Polystœchotes nebulosus*, metanotum: w^2, 2d wings.
FIG. 11. *Polystœchotes nebulosus*, mesosternum.
FIG. 12. *Polystœchotes nebulosus*, metasternum.
FIG. 13. *Polystœchotes nebulosus*, pronotum, seen laterally.
FIG. 14. *Polystœchotes nebulosus*, mesopleurum.
FIG. 15. *Polystœchotes nebulosus*, metapleurum.

All enlarged. William W. Griffin del., under author's direction.

PLATE LVII.

FIG. 1. *Pteronarcys californica*, pronotum.
FIG. 2. *Pteronarcys californica*, mesonotum.
FIG. 3. *Pteronarcys californica*, metanotum.
FIG. 4. *Corydalus cornutus*, end of abdomen of male, under side.
FIG. 5. *Corydalus cornutus*, end of abdomen of male, side view: *c*, cercopoda; *rh*, rhabdite.
FIG. 6. *Ascalaphus longicornis?*, abdomen.
FIG. 7. *Ascalaphus longicornis?*, abdomen.
FIG. 8. *Myrmeleon diversum*, abdomen of male, dorsal view.
FIG. 9. *Myrmeleon diversum*, abdomen of male, lateral view.
FIG. 10. *Myrmeleon diversum*, abdomen of male, ventral view.

All enlarged. William Griffin del.

PLATE LVIII.

FIG. 1. *Corydalus cornutus*, abdomen, dorsal view: *c*, cercopoda.
FIG. 2. *Polystœchotes nebulosus*, abdomen, dorsal view: *c*, cercopoda.
FIG. 3. *Polystœchotes nebulosus*, abdomen, ventral view: *c*, cercopoda.
FIG. 4. *Polystœchotes nebulosus*, abdomen, lateral view: *c*, cercopoda.
FIG. 5. *Raphidia oblita*, abdomen, dorsal view.
FIG. 6. *Raphidia oblita*, abdomen, lateral view.
FIG. 7. *Raphidia oblita*, abdomen, ventral view.

All enlarged. William W. Griffin del., under author's direction.

PLATE LIX.

FIG. 1. *Limnephilus pudicus*, head, seen from above: *p*, labial palpus.
FIG. 2. *Limnephilus pudicus*, head, seen from beneath.
FIG. 3. *Limnephilus pudicus*, head, seen from the side.
FIG. 4. *Limnephilus pudicus*: *mx*, 1st maxilla, *lac*, lacinia?
FIG. 5. *Limnephilus pudicus*, labrum.
FIG. 6. *Panorpa debilis?*, mouth-parts, showing labrum beneath.
FIG. 7. *Panorpa debilis?*, 2d maxilla (labium): *palpg*, palpiger; *p*, labial palpus.
FIG. 8. *Panorpa debilis?*, labrum.
FIG. 9. *Panorpa debilis?*, mandible.
FIG. 10. *Panorpa debilis?*, maxillæ and one palpus.

All magnified. Gissler del., under author's direction.

EXPLANATION OF PLATES.

PLATE LX.

FIG. 1. *Panorpa debilis?*, head, view from above.
FIG. 2. *Panorpa debilis?*, head, view from beneath.
FIG. 3. *Panorpa debilis?*, head, view from side.
FIG. 4. *Panorpa debilis?*, pronotum.
FIG. 5. *Panorpa debilis?*, mesonotum.
FIG. 6. *Panorpa debilis?*, metanotum.
FIG. 7. *Panorpa debilis?*, propleurum.
FIG. 8. *Panorpa debilis?*, mesopleurum.
FIG. 9. *Panorpa debilis?*, metapleurum.
FIG. 10. *Panorpa debilis?*, end of abdomen from the side; female, somewhat compressed.
FIG. 11. *Panorpa debilis?*, end of abdomen from above: *c*, jointed cercopoda.

All enlarged. Figs. 1–9 drawn by William W. Griffin; 10 and 11, by C. F. Gissler.

PLATE LXI.

FIG. 1. *Limnephilus pudicus*, pronotum.
FIG. 2. *Limnephilus pudicus*, mesonotum.
FIG. 3. *Limnephilus pudicus*, metanotum.
FIG. 4. *Limnephilus pudicus*, propleurum.
FIG. 5. *Limnephilus pudicus*, mesopleurum.
FIG. 6. *Limnephilus pudicus*, metapleurum.
FIG. 7. *Limnephilus pudicus*, abdomen.
FIG. 8. *Limnephilus pudicus*, abdomen, end; dorsal view.
FIG. 9. *Limnephilus pudicus*, abdomen, end; ventral view.

All enlarged. Gissler del., under author's direction.

PLATE LXII.

FIG. 1. Wing of pupa of *Blatta*: *c*, costal; *sc*, subcostal; *m*, median; *sm*, submedian; *int*, internal view.
FIG. 2. *Termes flavipes*: *A*, young pupa; a, 1st wing; *B*, advanced pupa; *b*, wings; *n*, veins.
FIG. 3. Wings of *Termes flavipes*, just before imago state.
FIG. 4. Adult *Termes*, enlarged.
FIG. 5. Wings of pupal *Psocus*.

All enlarged. C. F. Gissler del.

Note.—Plates LXII and LXIII illustrate pp. 268–271, on the development of the wings; the references in the text are imperfect.

PLATE LXIII.

FIG. 1. *Aphrophora permutata*, pupa; ventral view.
FIG. 2. *Aphrophora permutata*, pupa; dorsal view.
FIG. 3. *Aphrophora permutata*, pupa, rudimentary wing: *sc*, scutellum: 1 *ab*, 1st abdominal segment.
FIG. 4. Thorax of *Æschna heros*: 1–5, the five main veins of the wing.

All enlarged. C. F. Gissler del.

PLATE LXIV.

FIG. 1. *Corydalus cornutus*, propleurum.
FIG. 2. *Corydalus cornutus*, mesopleurum.
FIG. 3. *Corydalus cornutus*, metapleurum.
FIG. 4. *Corydalus cornutus*, prosternum.
FIG. 5. *Corydalus cornutus*, mesosternum.
FIG. 6. *Corydalus cornutus*, metasternum.
FIG. 7. *Corydalus cornutus*, mesonotum.
FIG. 8. *Corydalus cornutus*, metanotum.

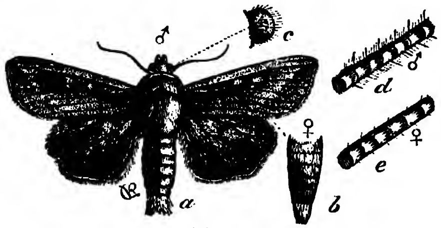


Fig. 1.

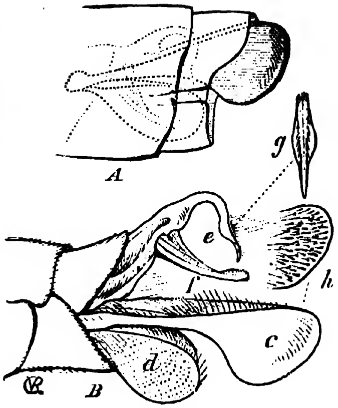


Fig. 2.

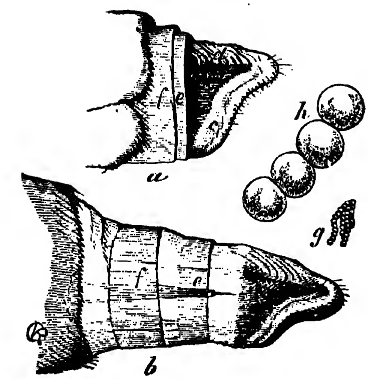


Fig. 3.

Fig. 4.

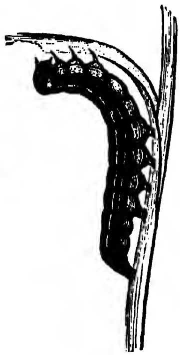


Fig. 5.

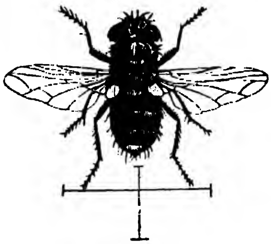


Fig. 6.

Fig 4.

Fig. 7.

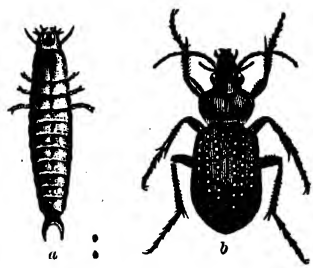


Fig. 8.

THE ARMY WORM AND ENEMIES.

Fig. 1.

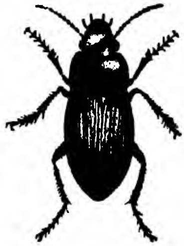


Fig. 2.

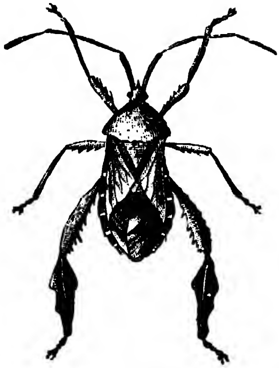


Fig. 3.

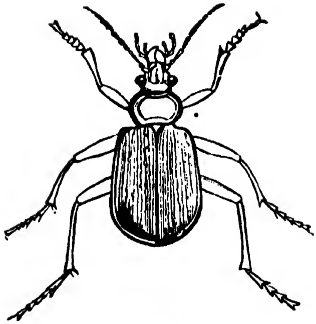


Fig. 4.

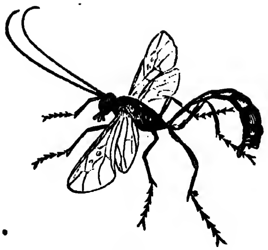


Fig. 5.

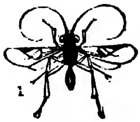


Fig. 6.

Fig. 7.

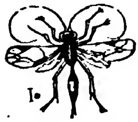


Fig. 8.

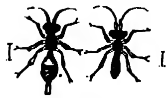


Fig. 9.

Enemies and Parasites of the Army Worm.

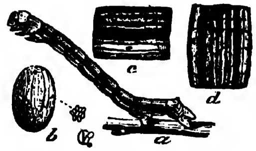


Fig. 1.

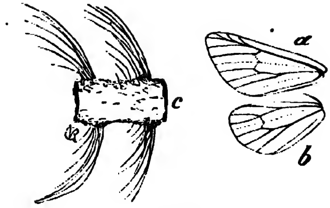


Fig. 2.

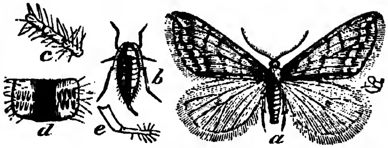


Fig. 3.

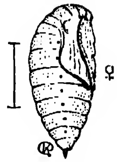


Fig. 4.

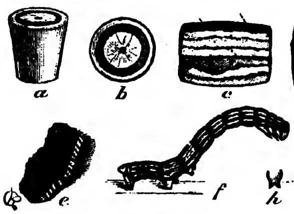


Fig. 5.

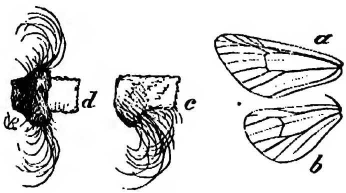


Fig. 6.

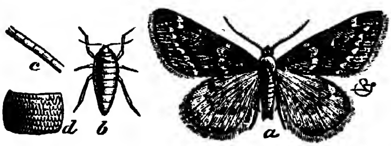


Fig. 7.

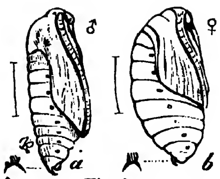
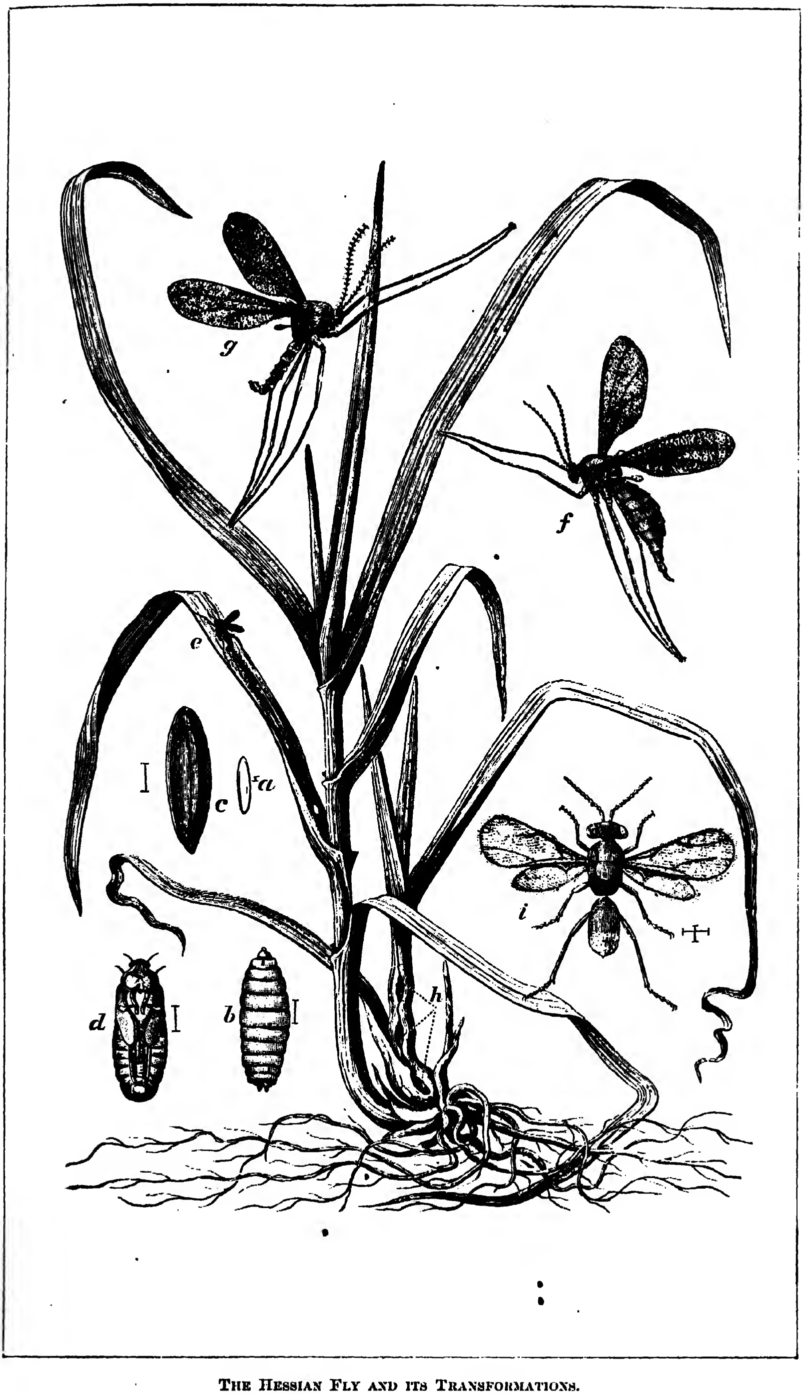
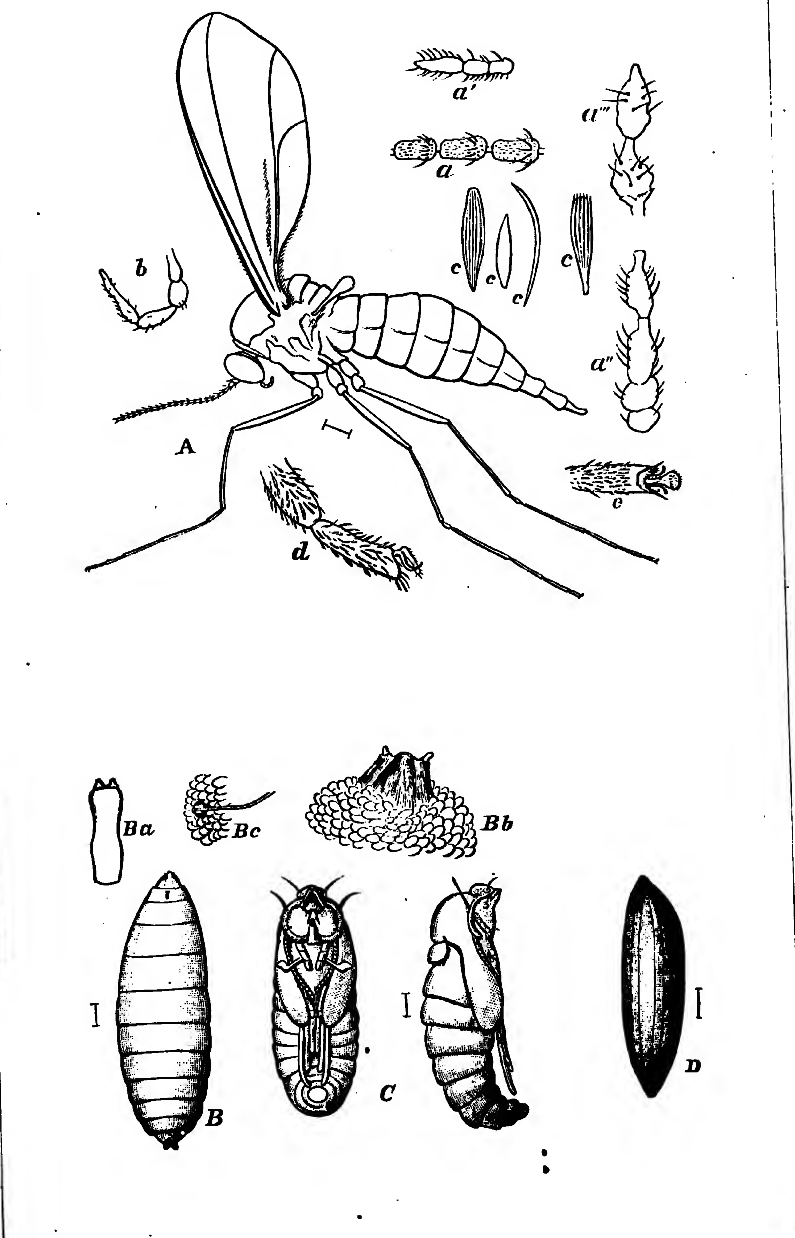


Fig. 8.

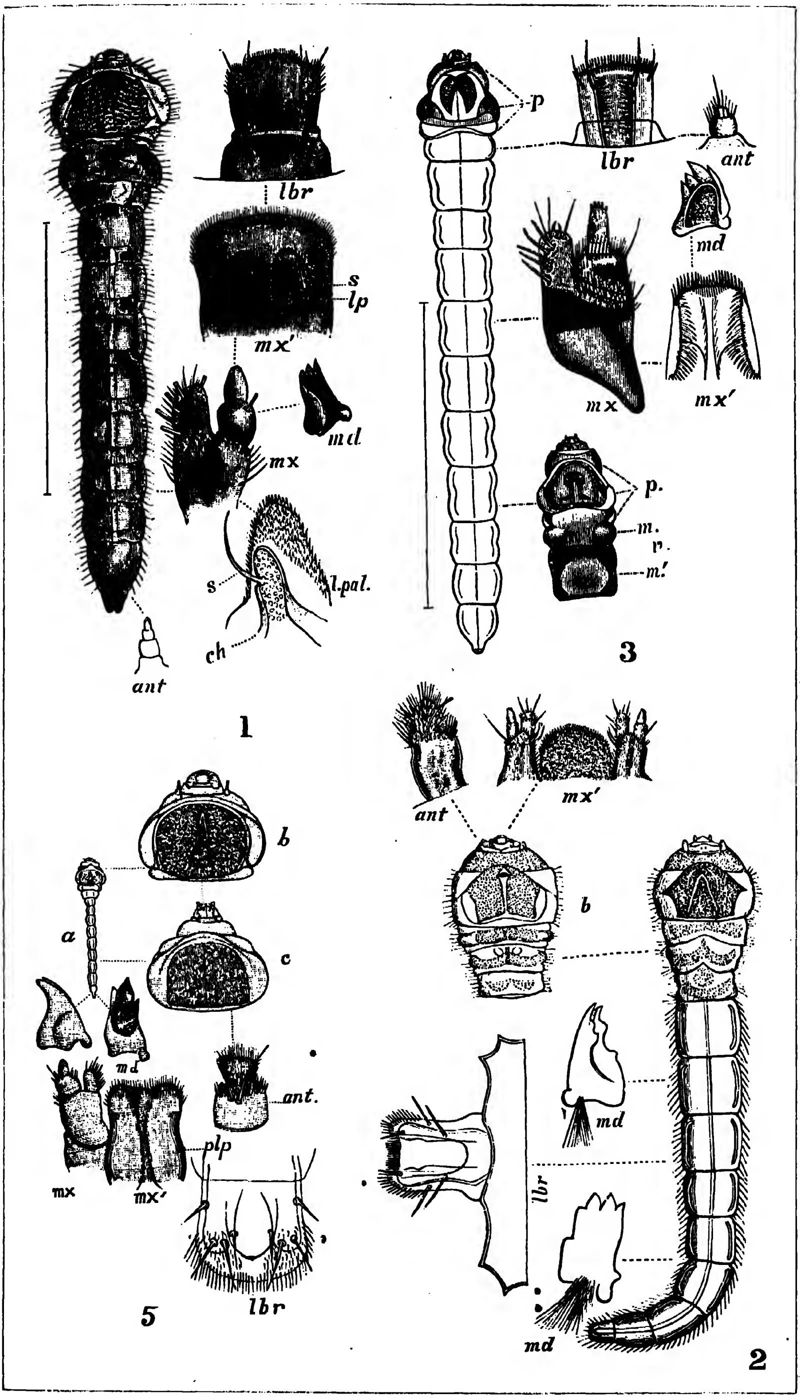
Canker Worms.



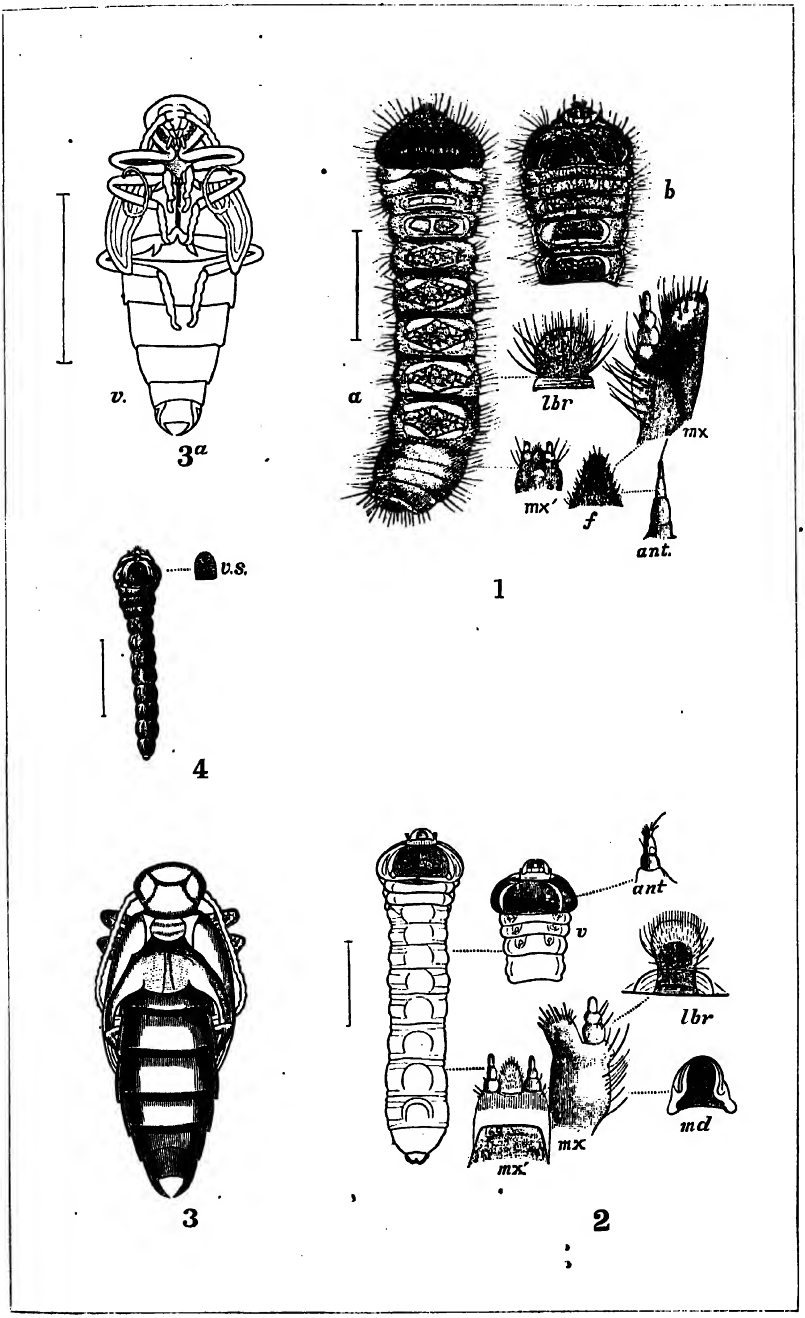
THE HESSIAN FLY AND ITS TRANSFORMATIONS.



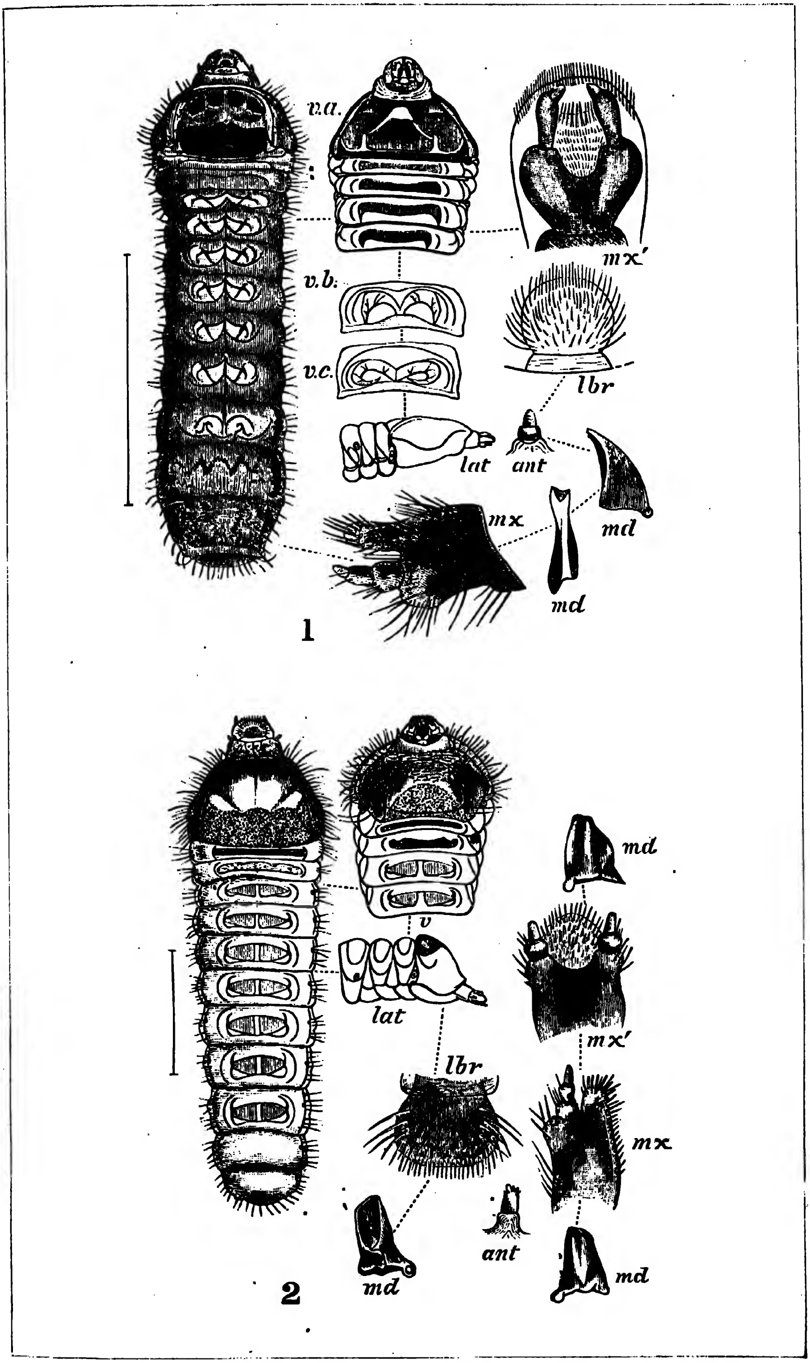
TRANSFORMATIONS OF THE HESSIAN FLY.



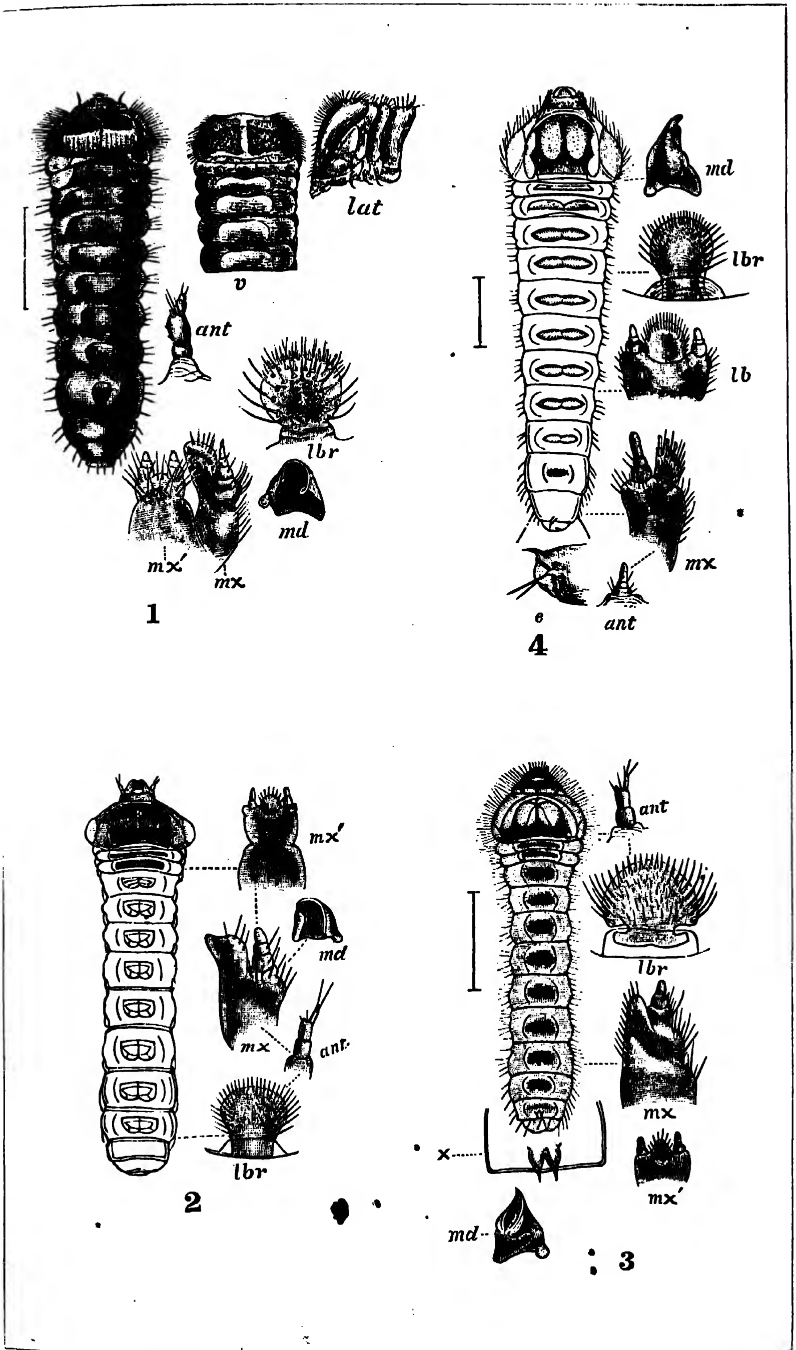
1. Chalcophora virginica? 2. Dicerca divaricata. 3, 5. Unknown.



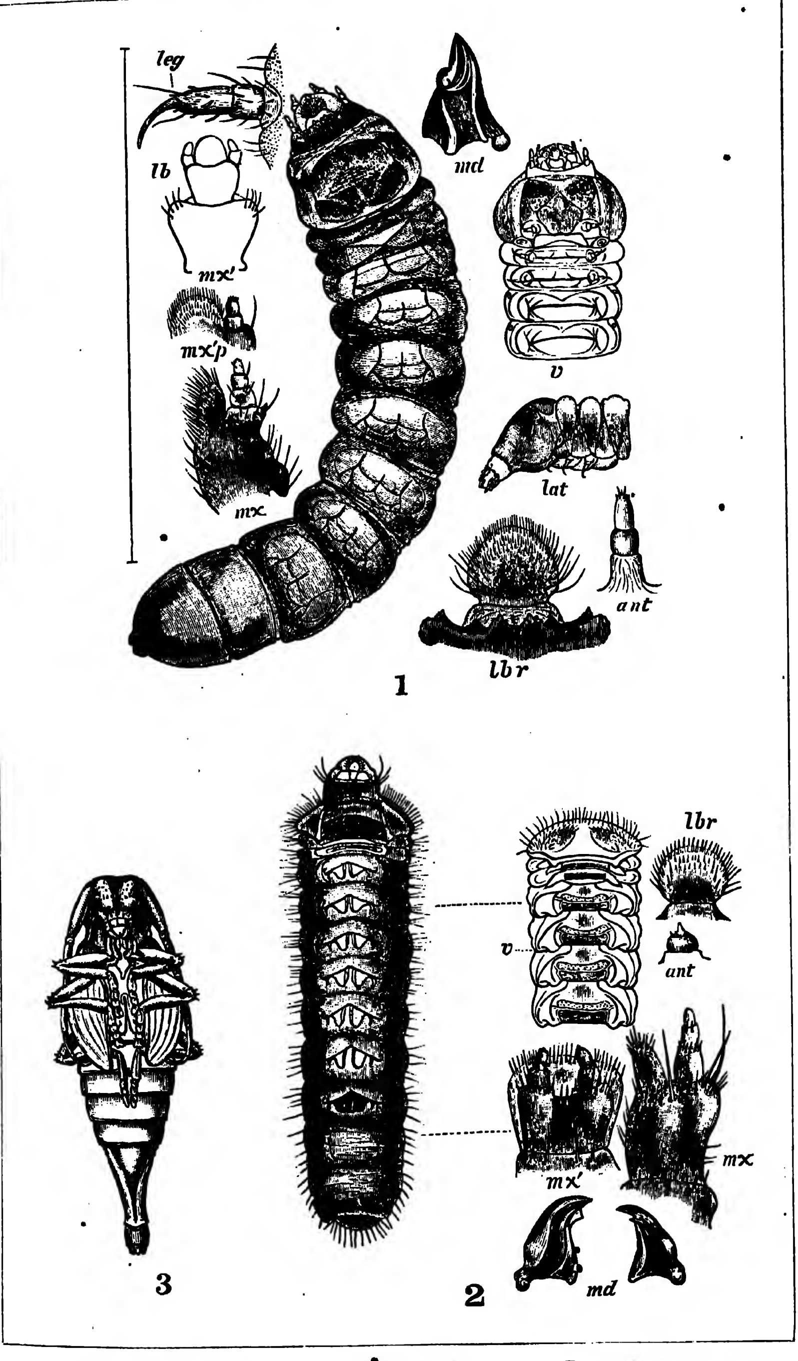
1. Elaphidion parallelum.
2. Unknown.
3, 3a. Criocephalus agrestis
4. Melanophila.



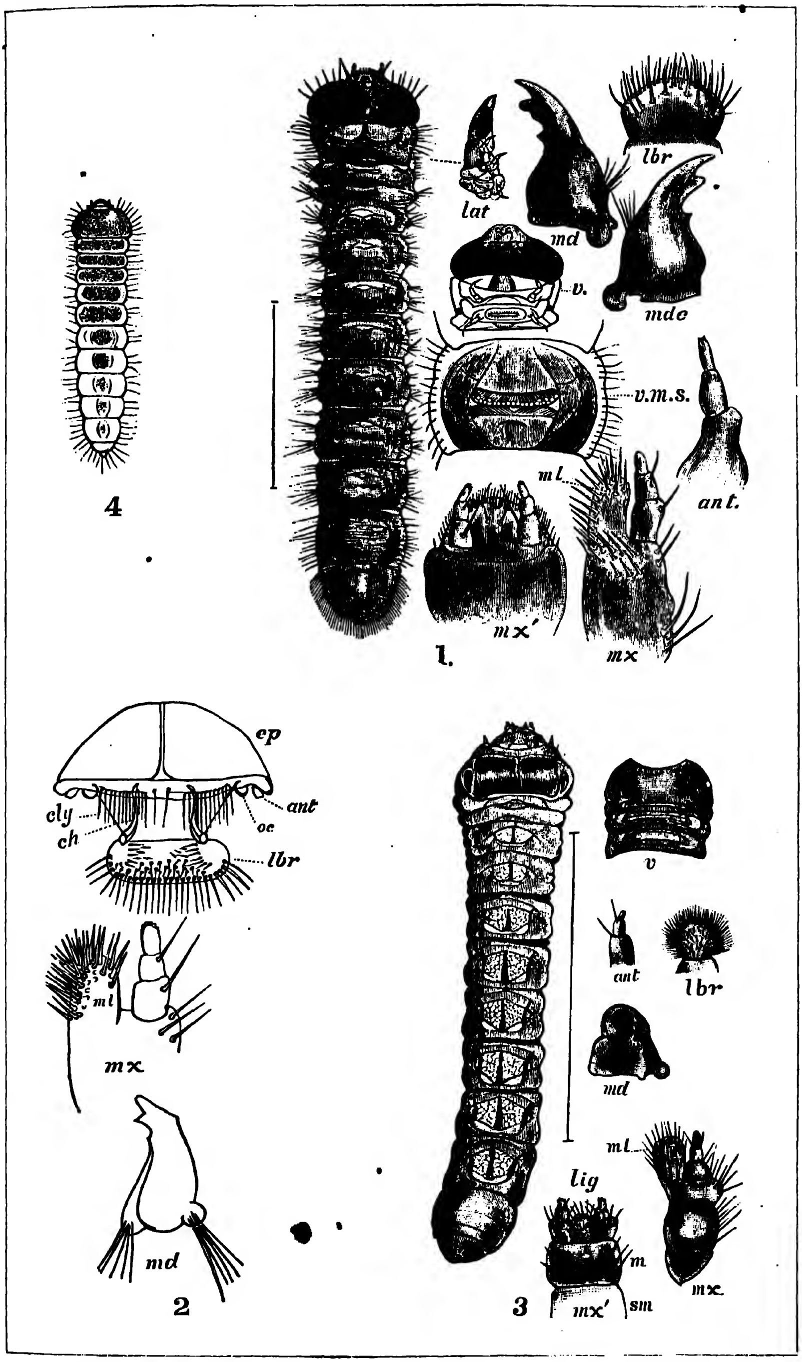
1. LONGICORN LARVA, FROM PITCH PINE. 2. SAPERDA TRIDENTATA BORING IN THE ELM.



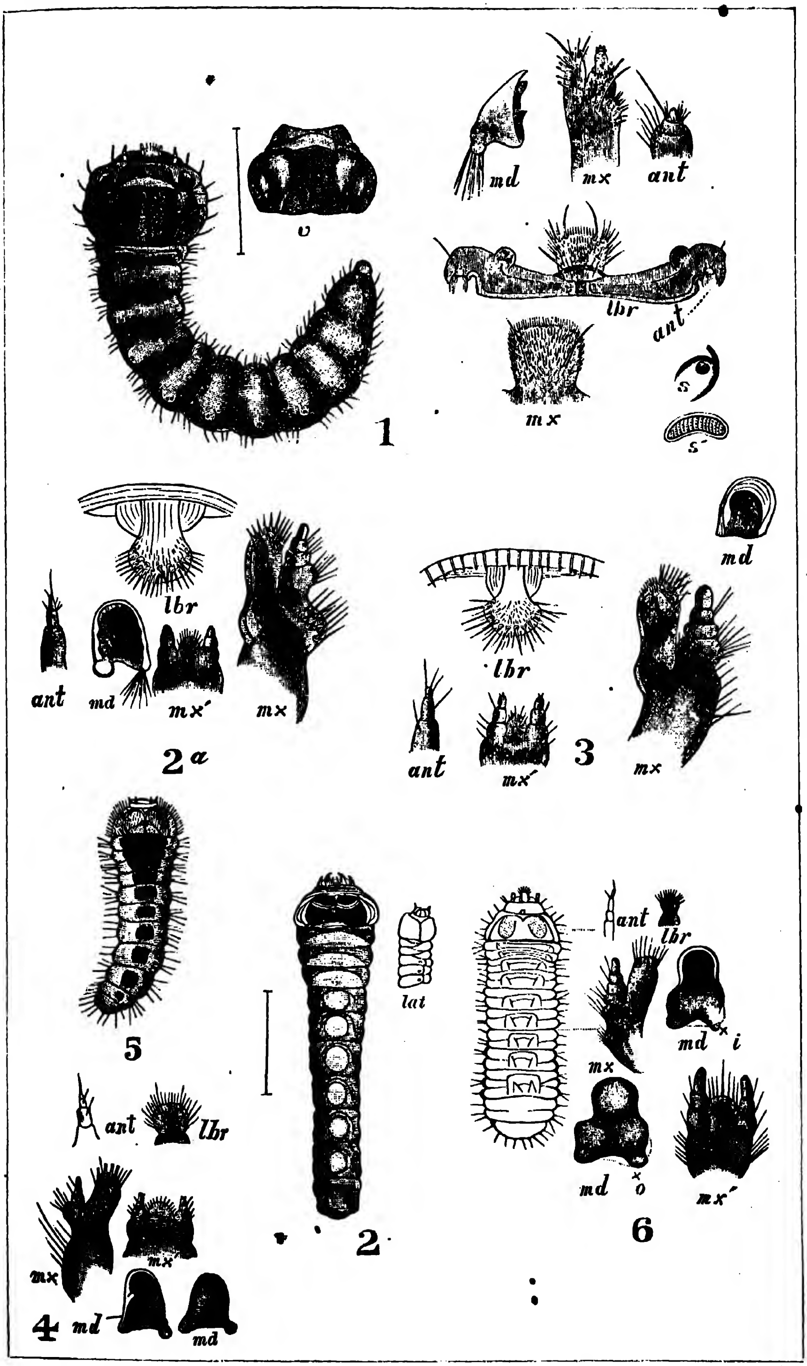
1. Asemum mœstum.
3. Larva, in white pine.
2. Larva, living in oak.
4. Larva, in sweet gum.



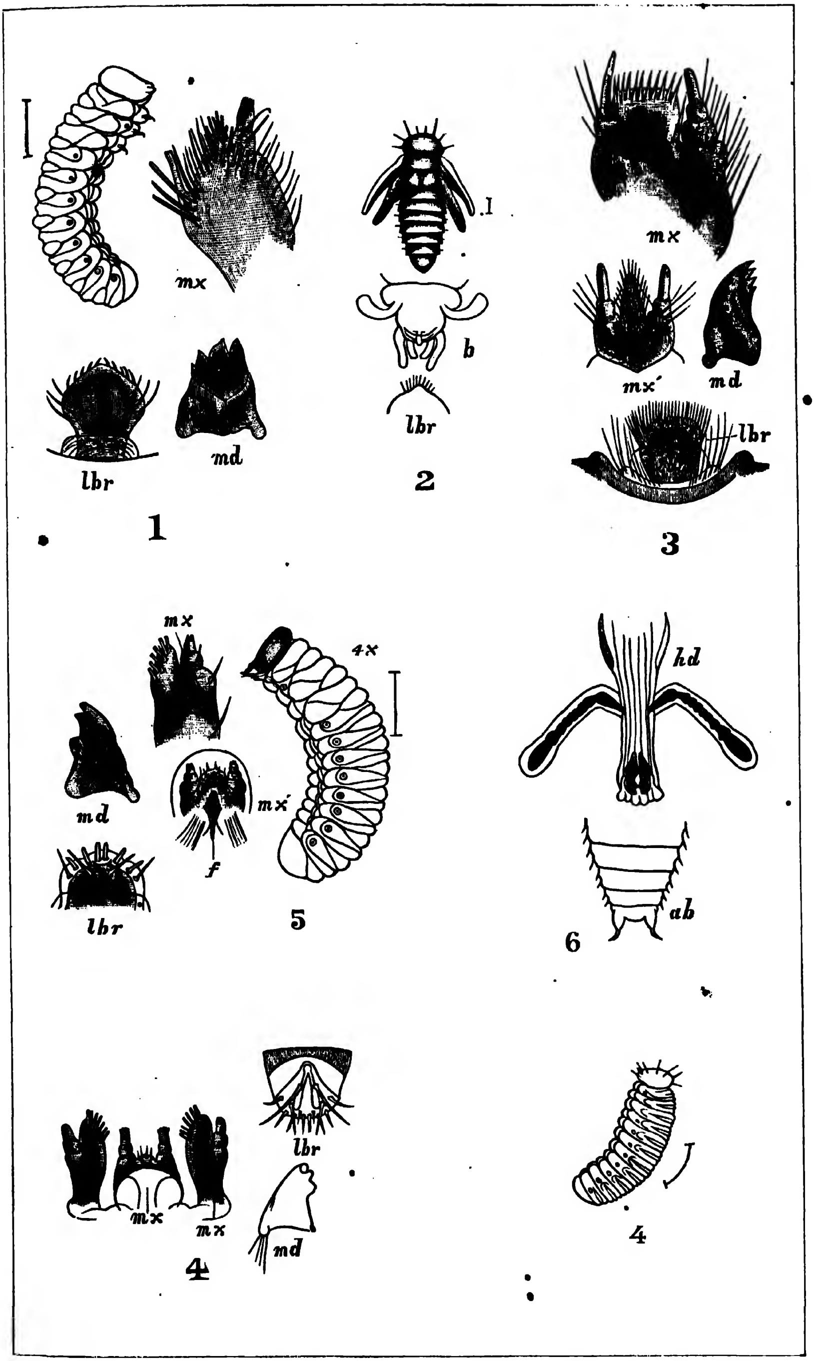
1. Orthosoma brunneum. 2. Sycamore borer. 3. Pupa, under oak bark.



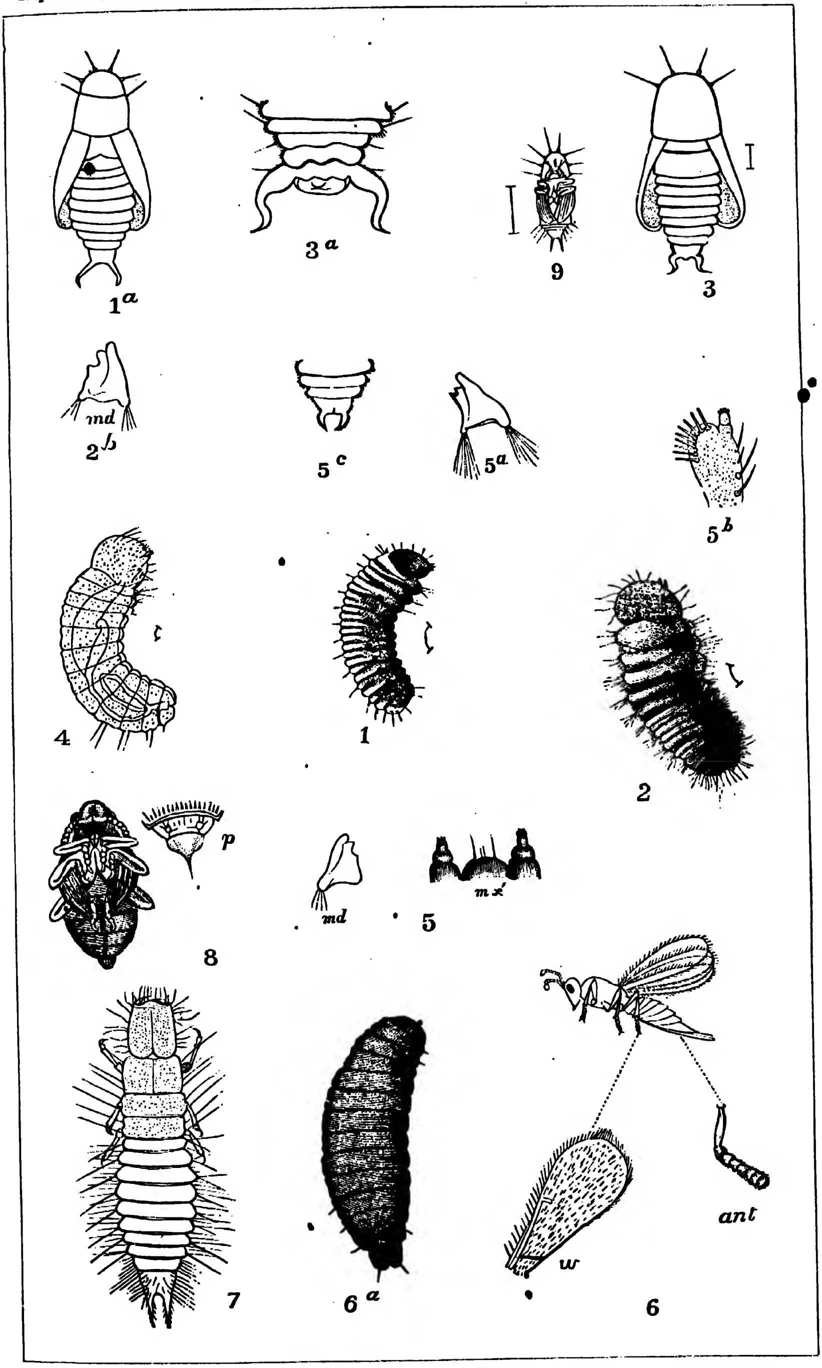
1, 2. Rhagium lineatum, in pine. 3. Larva, in oak. 4. Saperda, from willow.



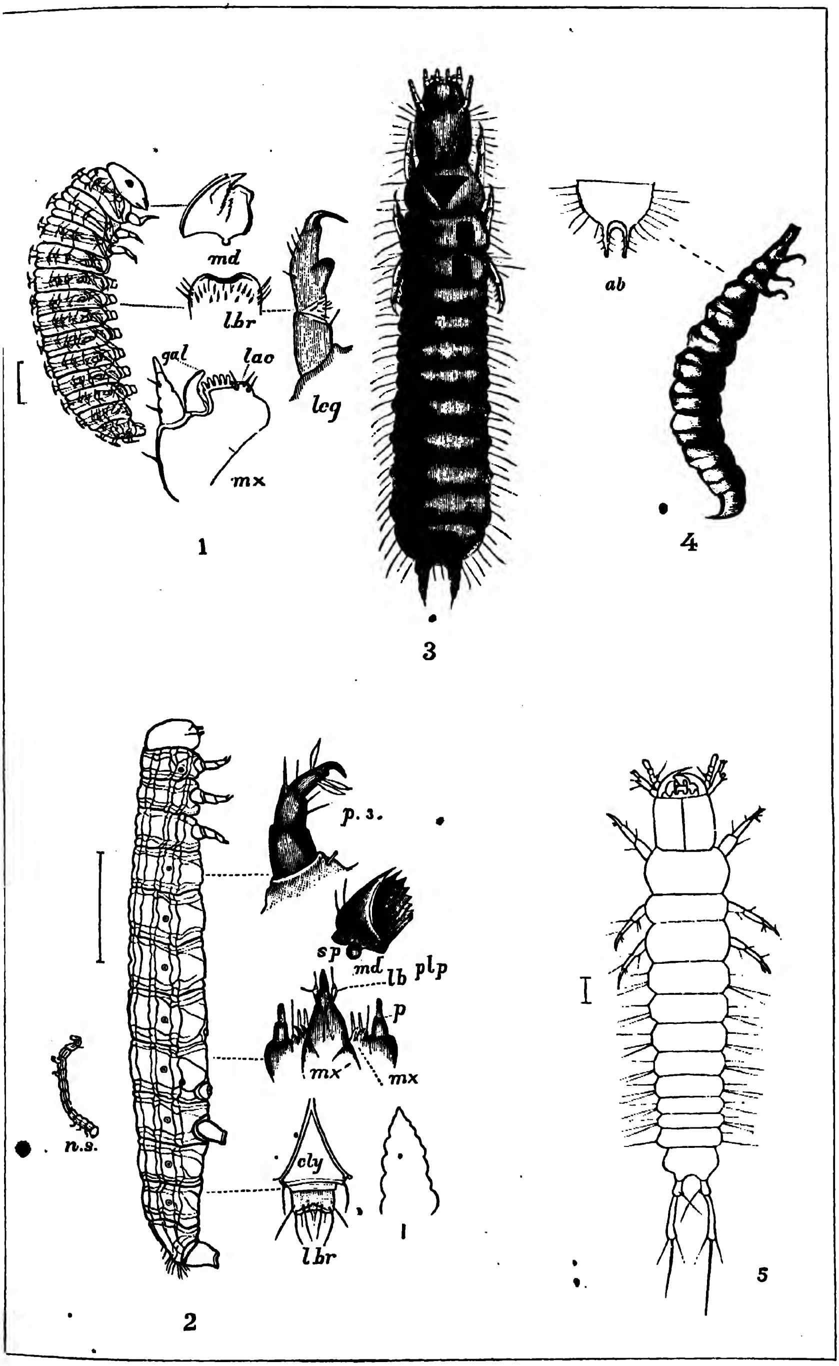
1. Melanophila. 2, 2a, 3. Xylotrechus colonus.
4. Details of willow Saperda. 5, 6. Hemlock borers.



1, 2. Unknown. 3. Xestobium affine. 4. Hylurgops pinifex. 5, 6. Pissodes strobi.

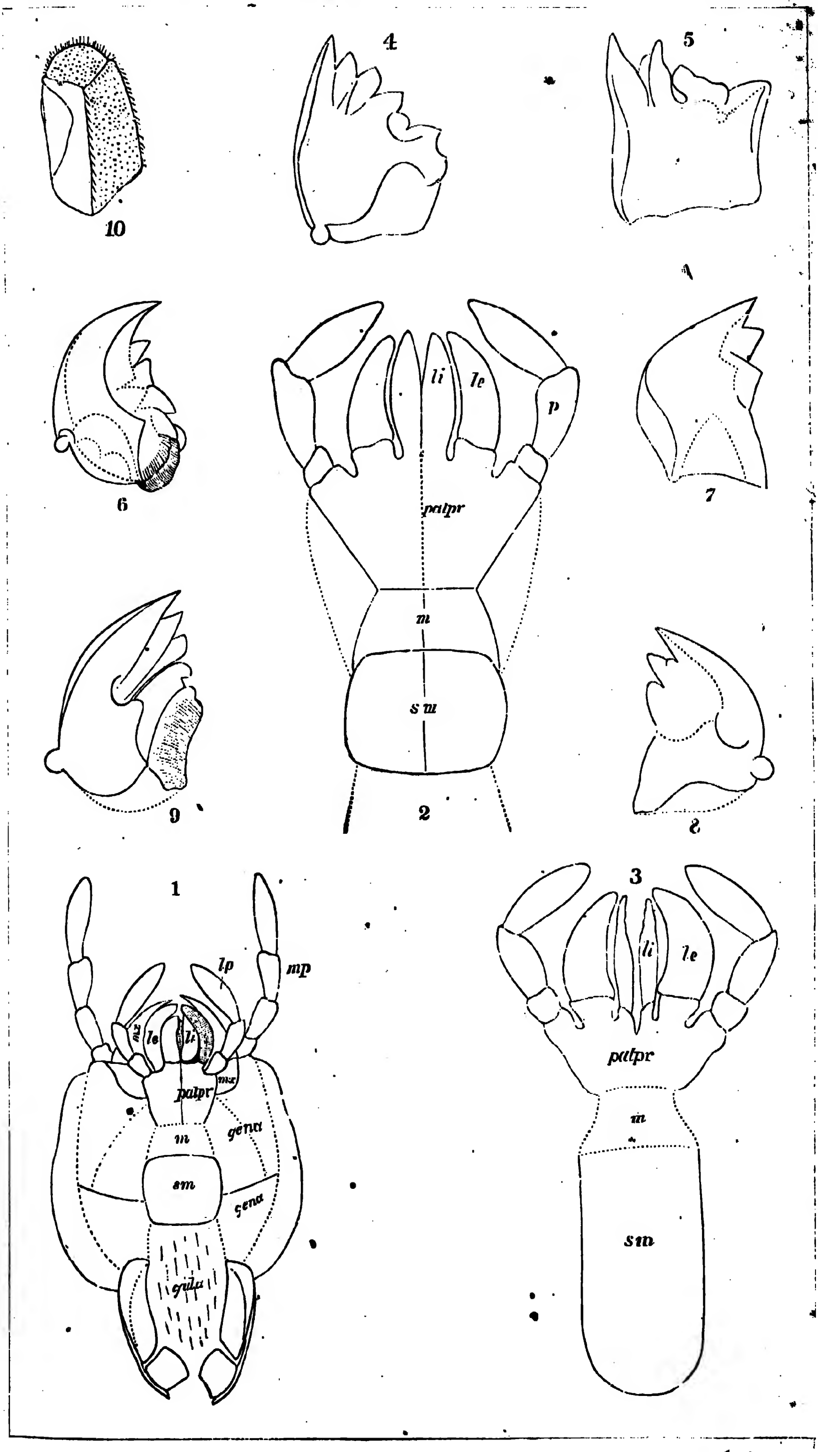


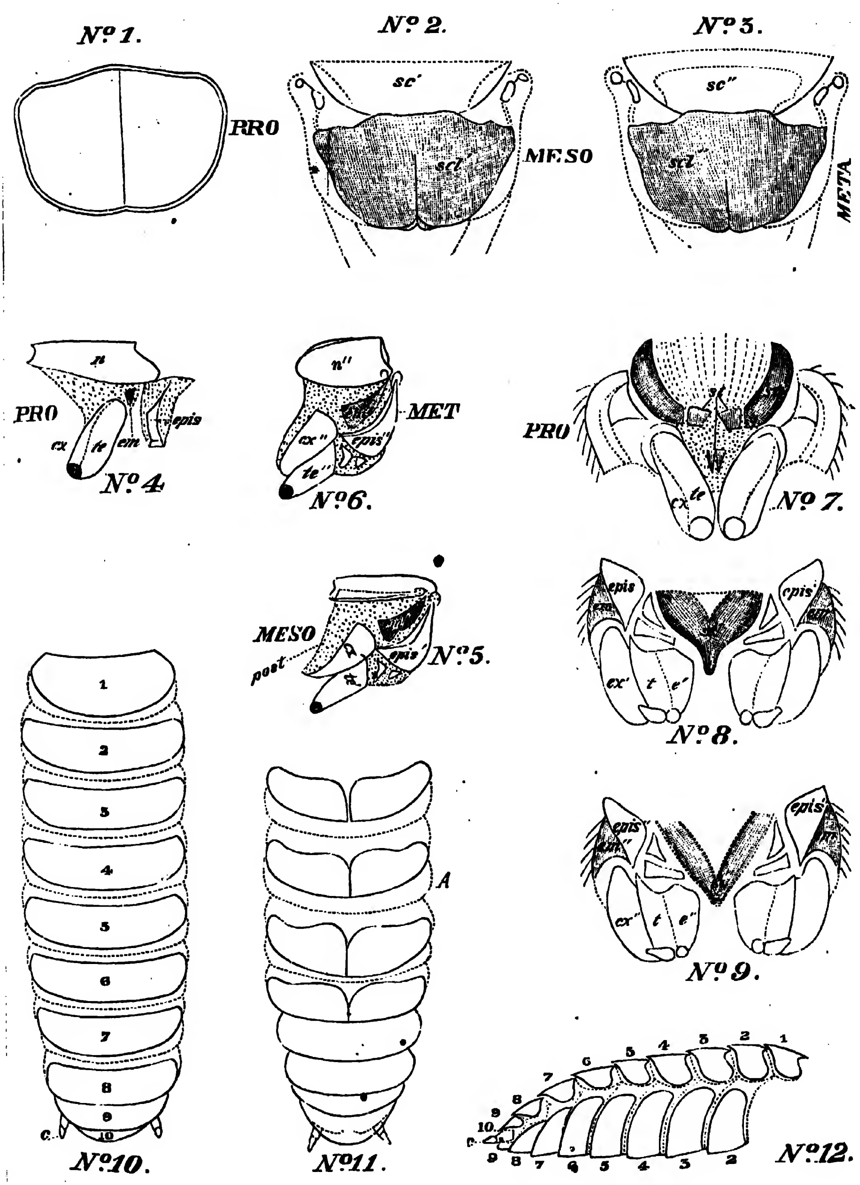
1, 1a. XYLOTERES. 2–3a. XYLEBORUS. 4–5c. CRYPTURGUS ATOMUS.
6–8. MISCELLANEOUS. 9. PUPA OF HYLURGOPS PINIFEX.



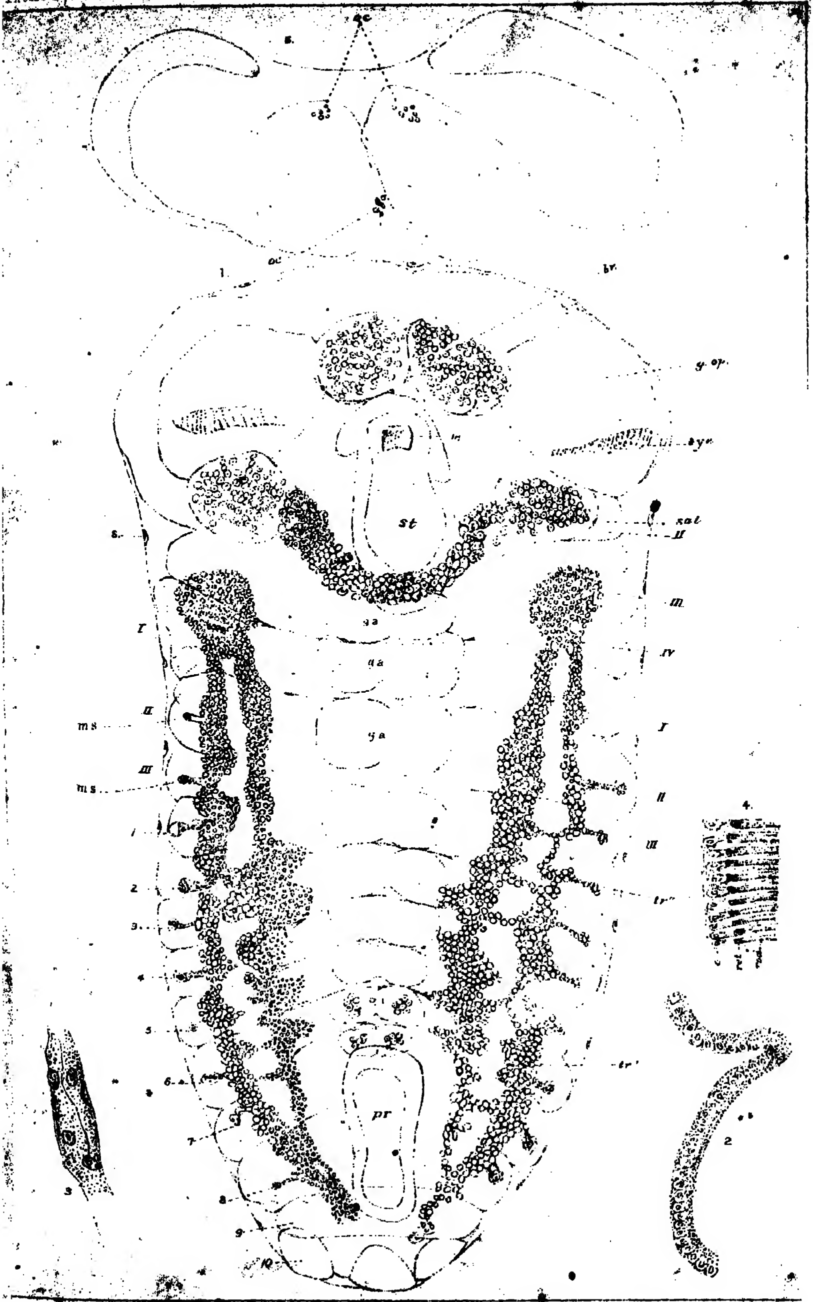
1. Selandria, on hickory.
2. Deltoid larva, on hickory.

3–5. Coleopterous larvæ, attacking pine bark-borers.

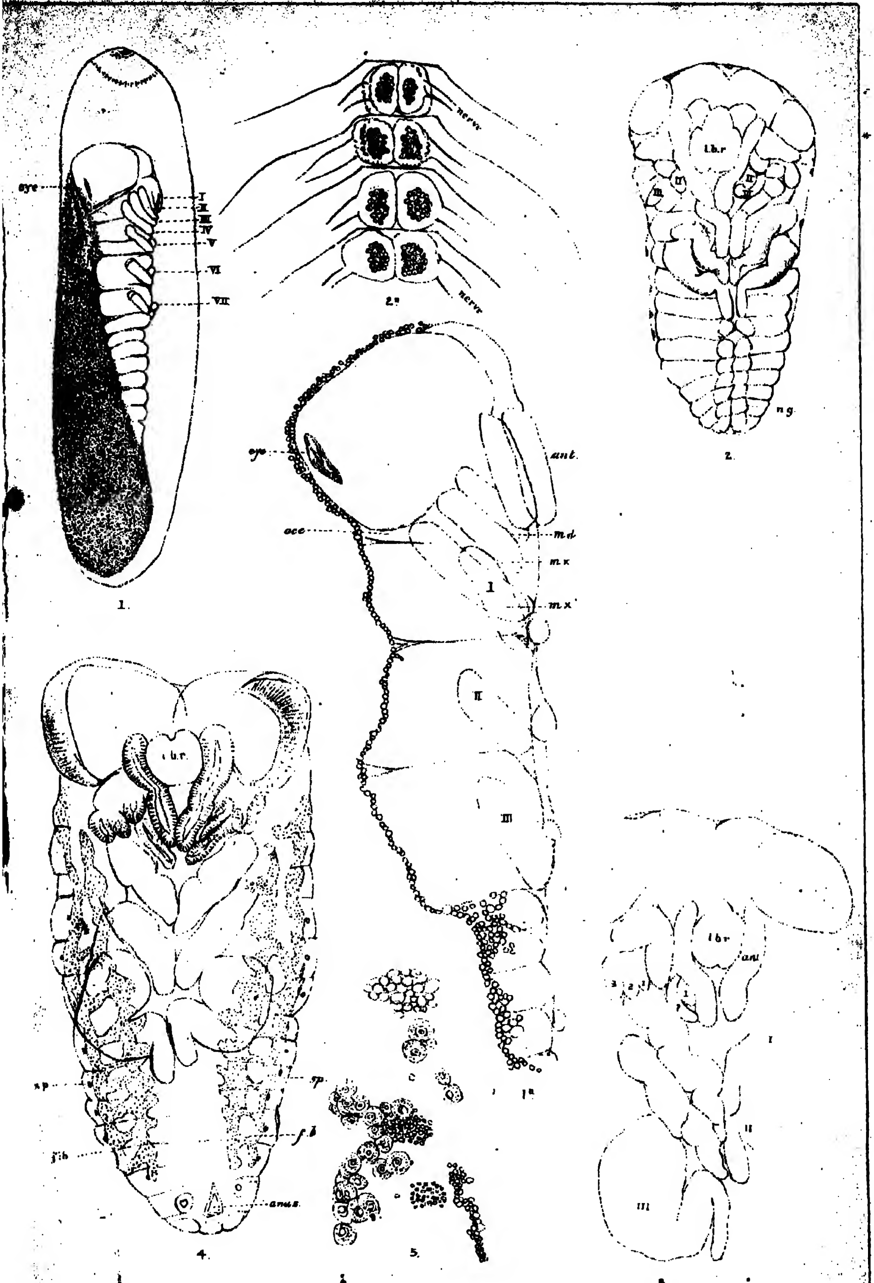

10
4
5
6
li
le
p
palpr
m
sm
2
7
9
8
1
lp
mp
mx
le
li
palpr
mx
m
gena
sm
gena
gula
3
li
le
palpr
m
sm



TERMES FLAVIPES.

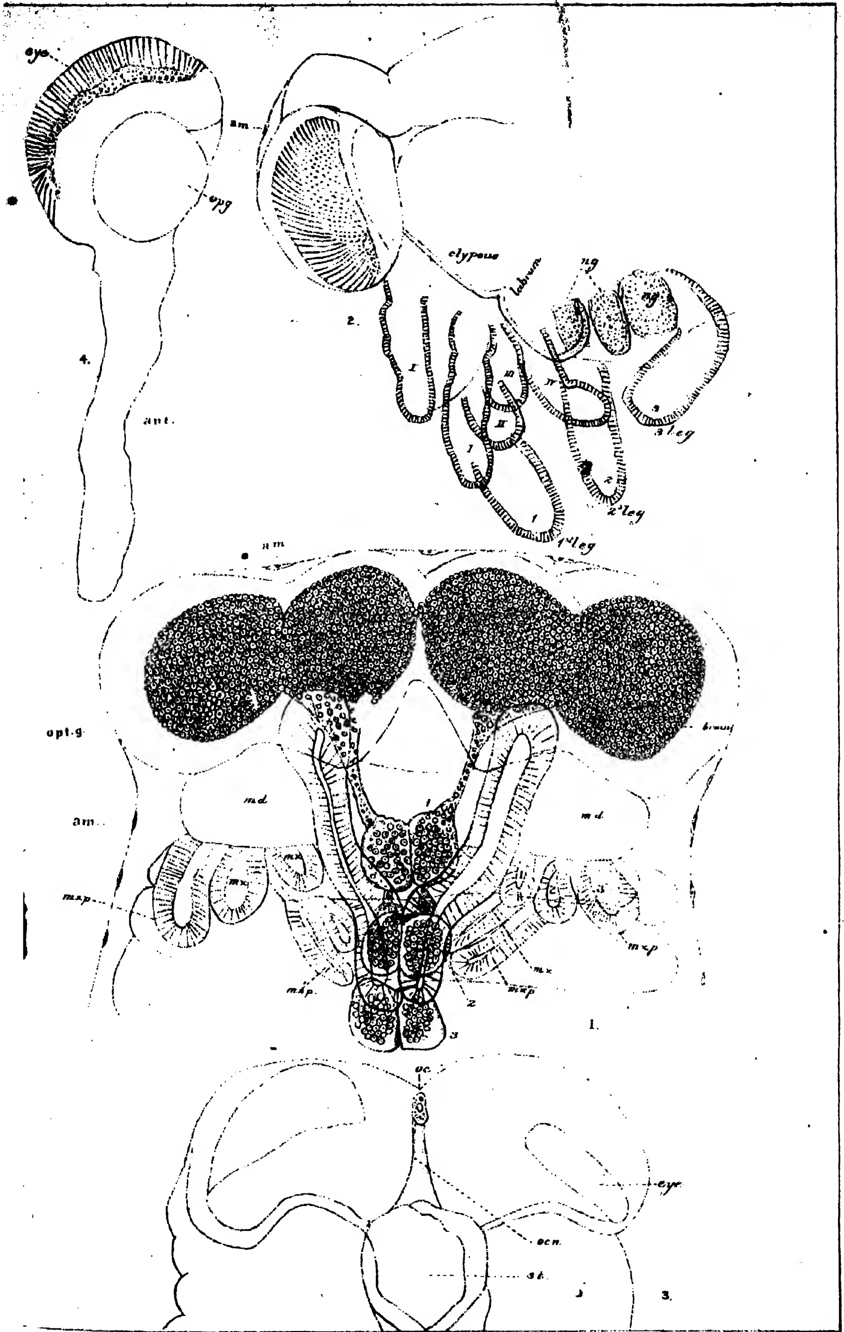

oc
s
1.
oc
br.
g. op.
m
eye
st
sal
II
s.
III
I
IV
ga
ga
ga
V
II
ms
III
ms
II
III
1
2
3
4
5
6
7
8
9
10
pr
tr
tr
4.
2
3

Packard, del.



Packard, del.

EMBRYOLOGY OF CALOPTENUS SPRETUS.

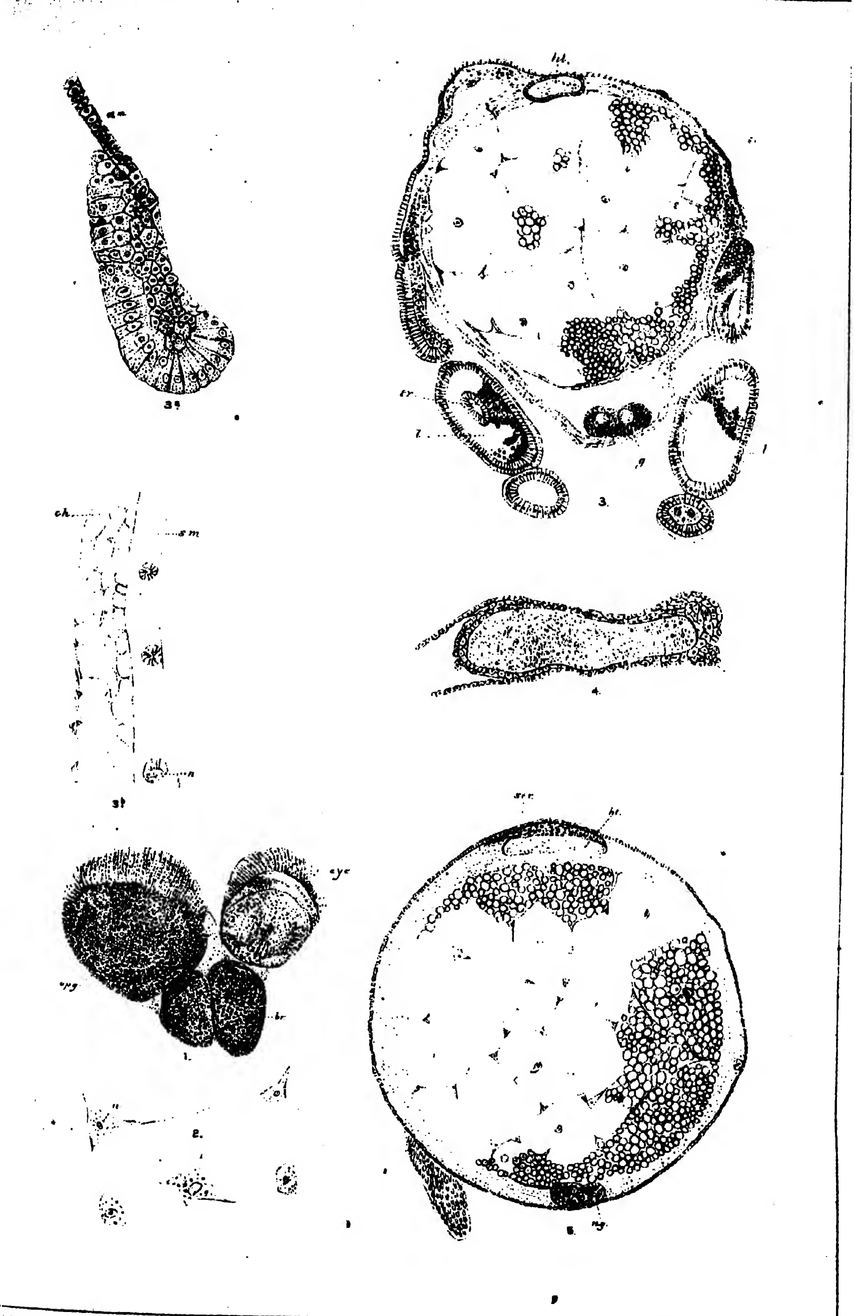


[Pa]ckard, del. Heliotype Printing Co.

EMBRYOLOGY OF CALOPTENUS SPRETUS.

Packard del. Heliotype Printing Co. Boston.

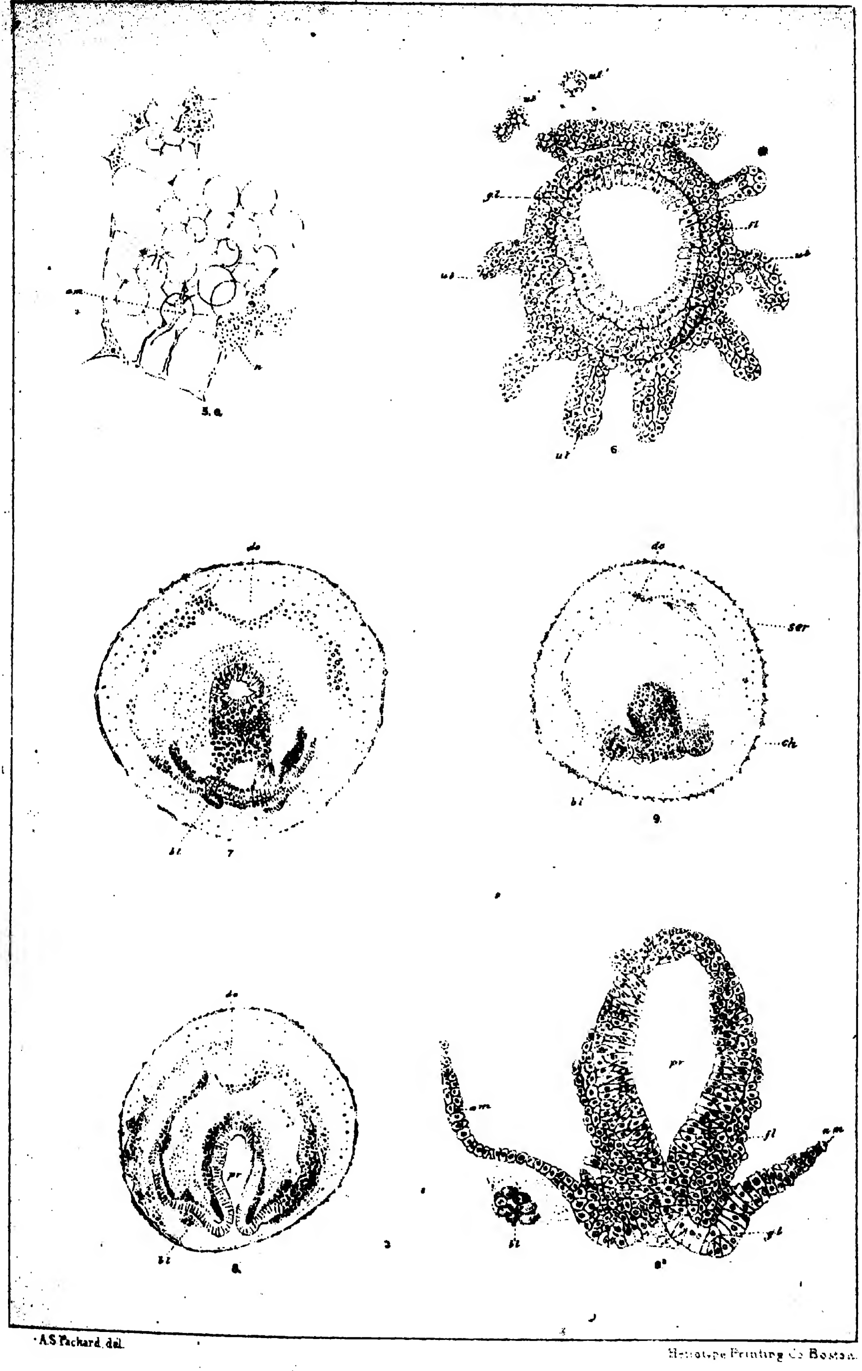
EMBRYOLOGY OF CALOPTENUS SPRETUS.



A. S. Packard del.

Heliotype Printing Co. Boston.

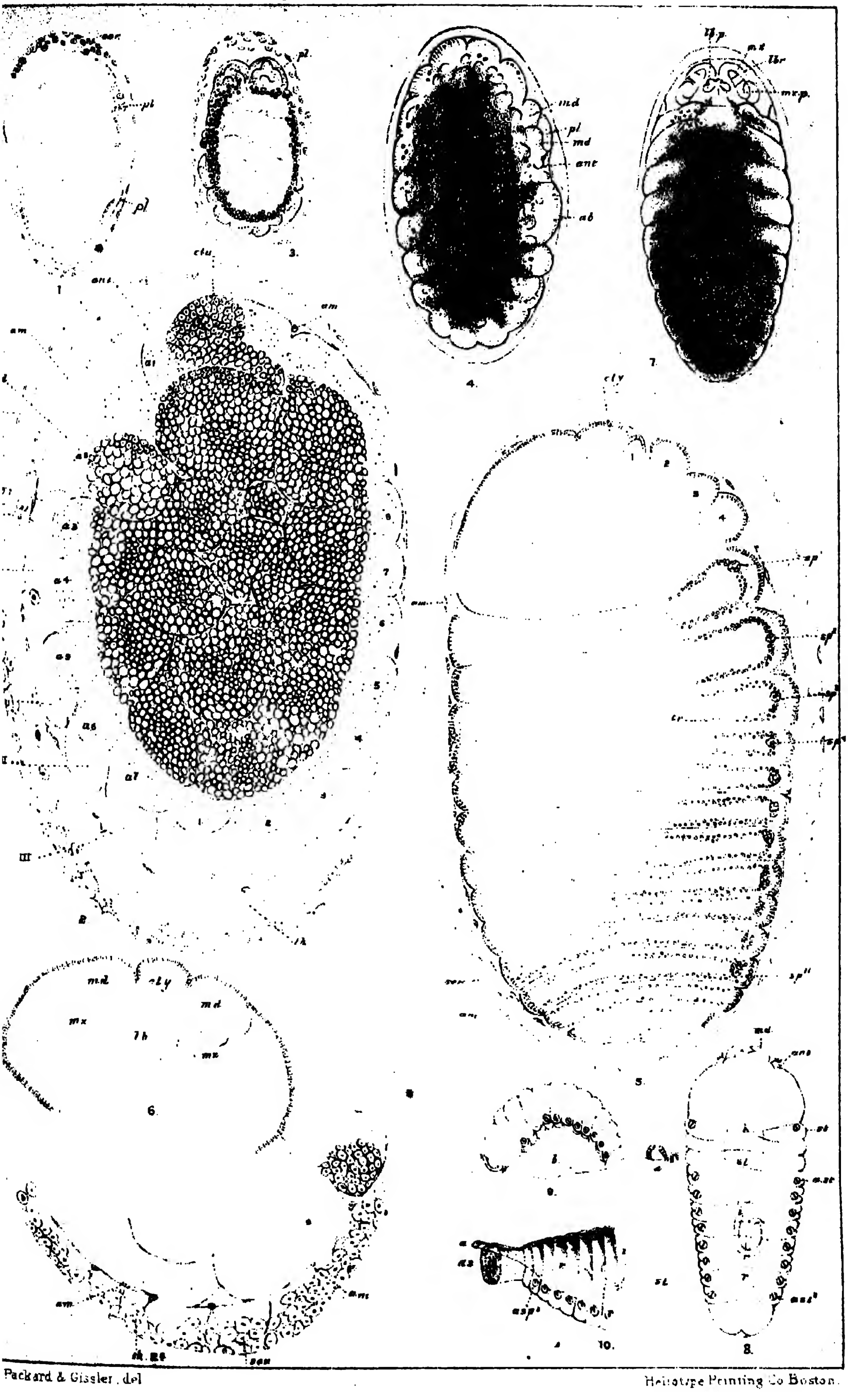
EMBRYOLOGY OF CALOPTENUS ATLANIS.



A S Packard, del.

Heliotype Printing Co Boston.

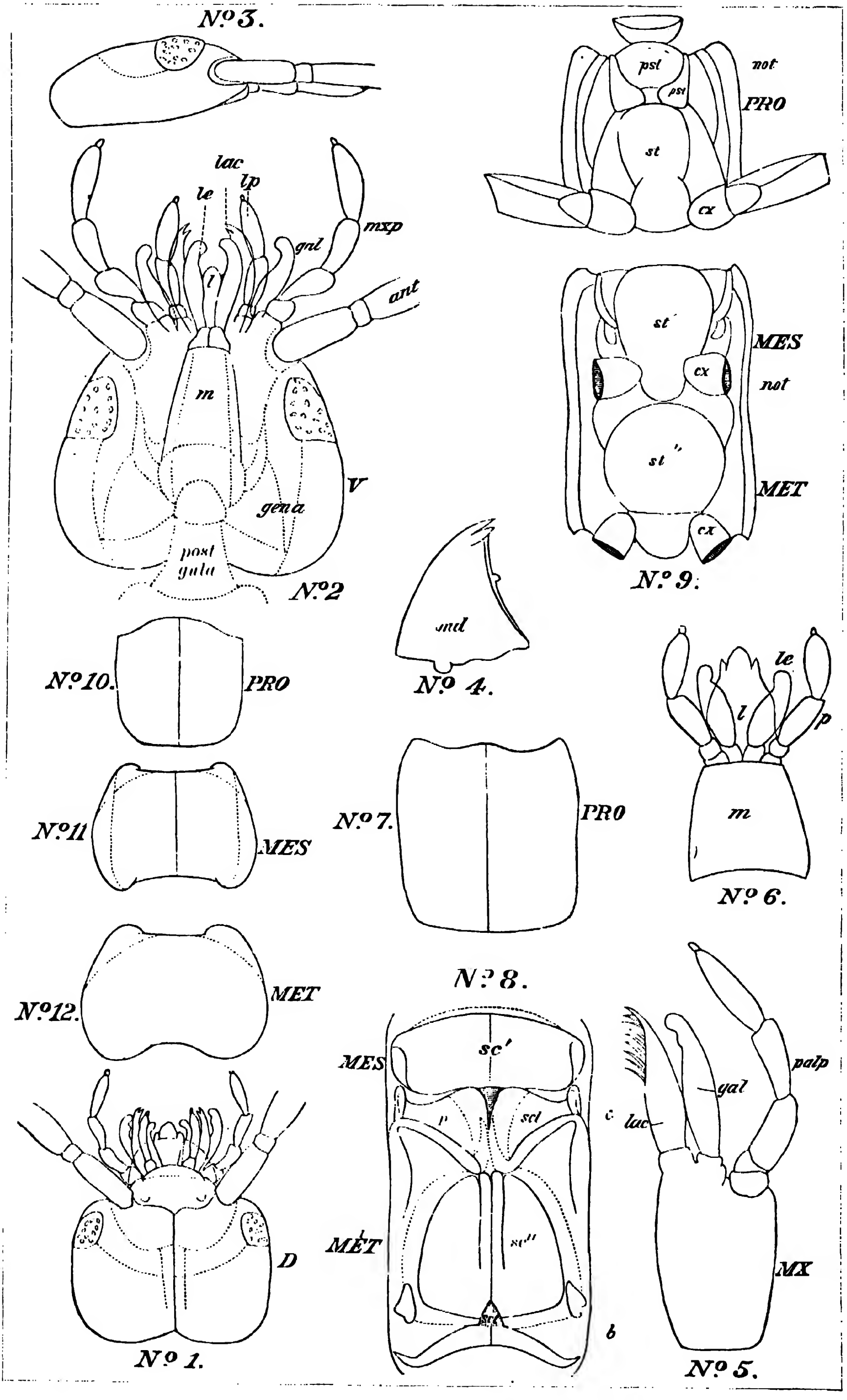
EMBRYOLOGY OF CALOPTENUS ATLANIS



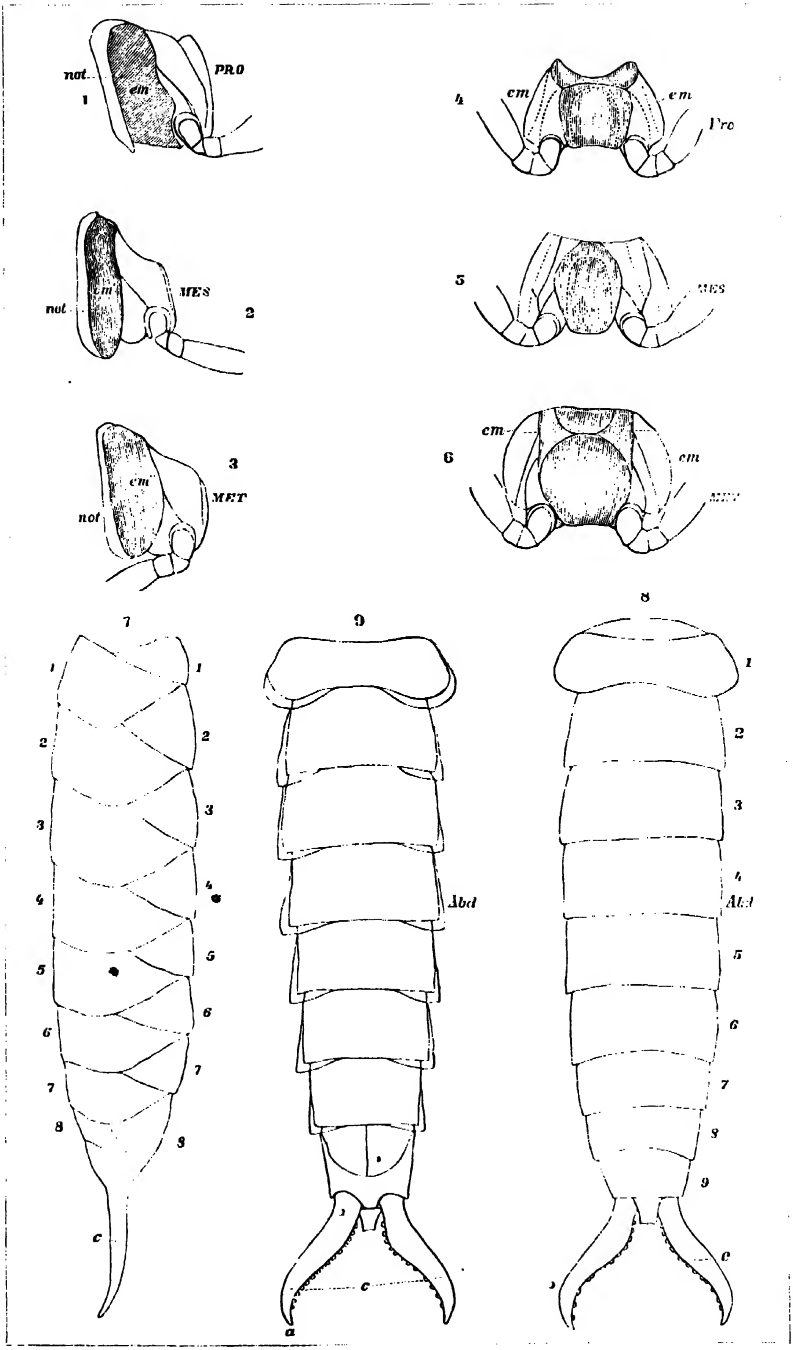
Packard & Gissler, del.

Heliotype Printing Co Boston.

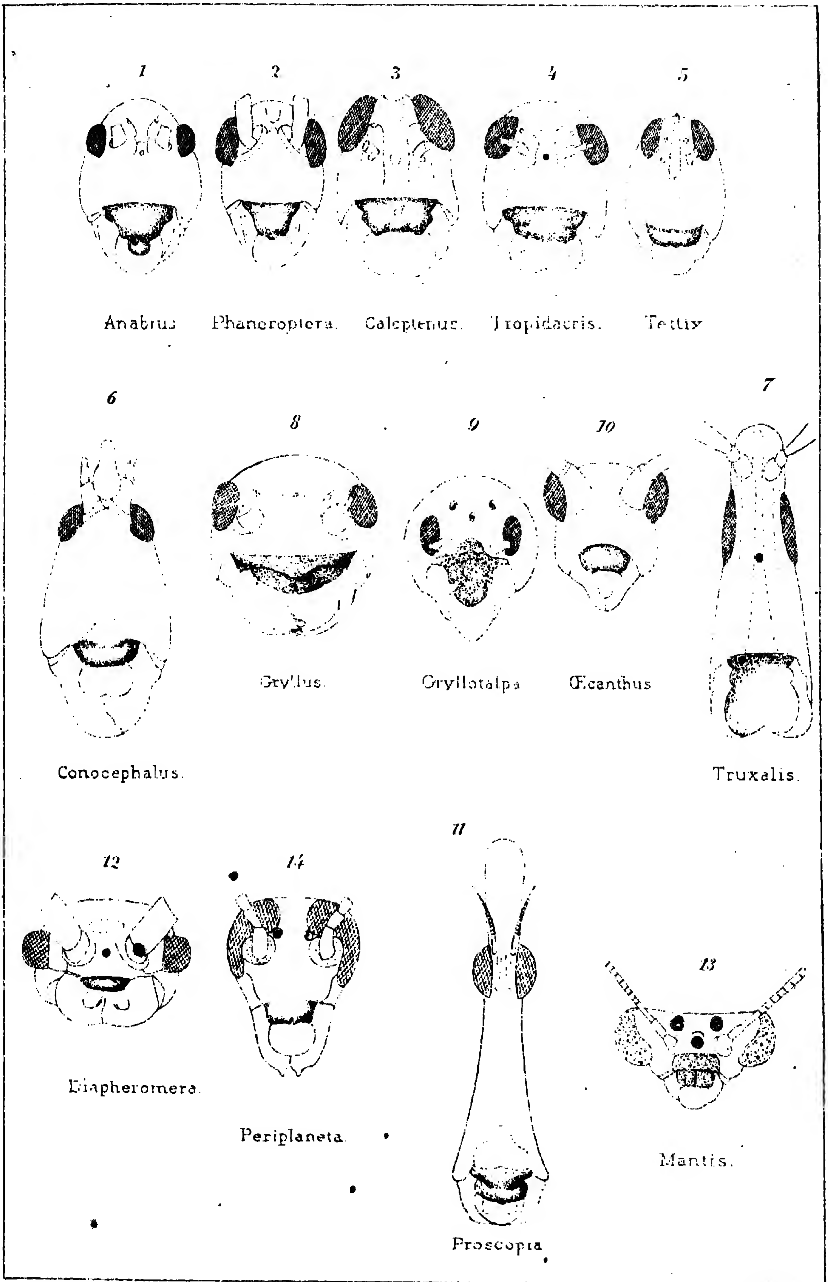
XYLEBORUS AND HYLURGOPS.



1–9. Forficula tæniata. 10–12. Forficula, larva.

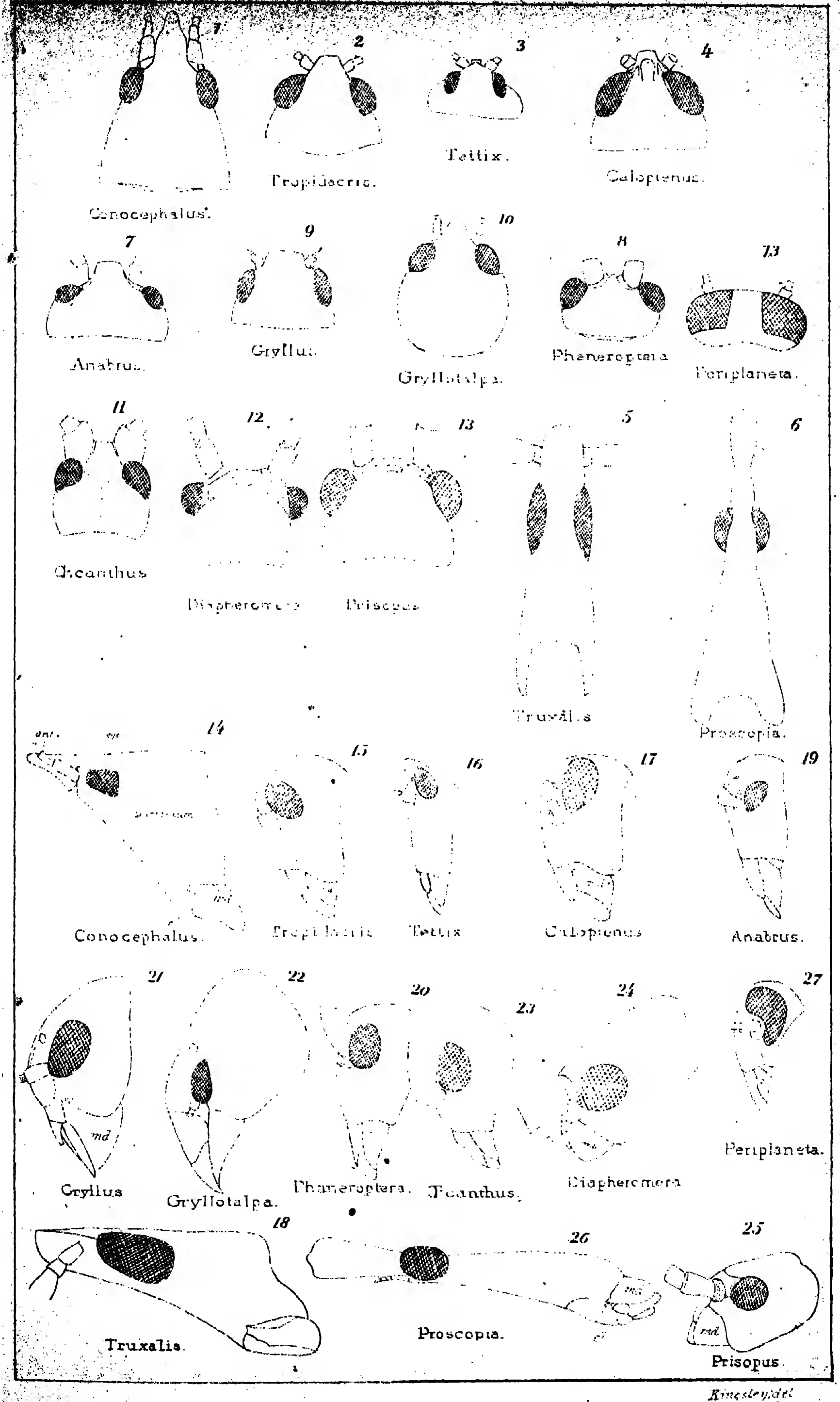

not
1
em
PRO
2
em
MES
not
3
em
MET
not
4
cm
em
Pro
5
MES
6
cm
cm
7
1
2
3
4
5
6
7
8
c
9
Abd
c
a
8
1
2
3
4
Abd
5
6
7
8
9
c

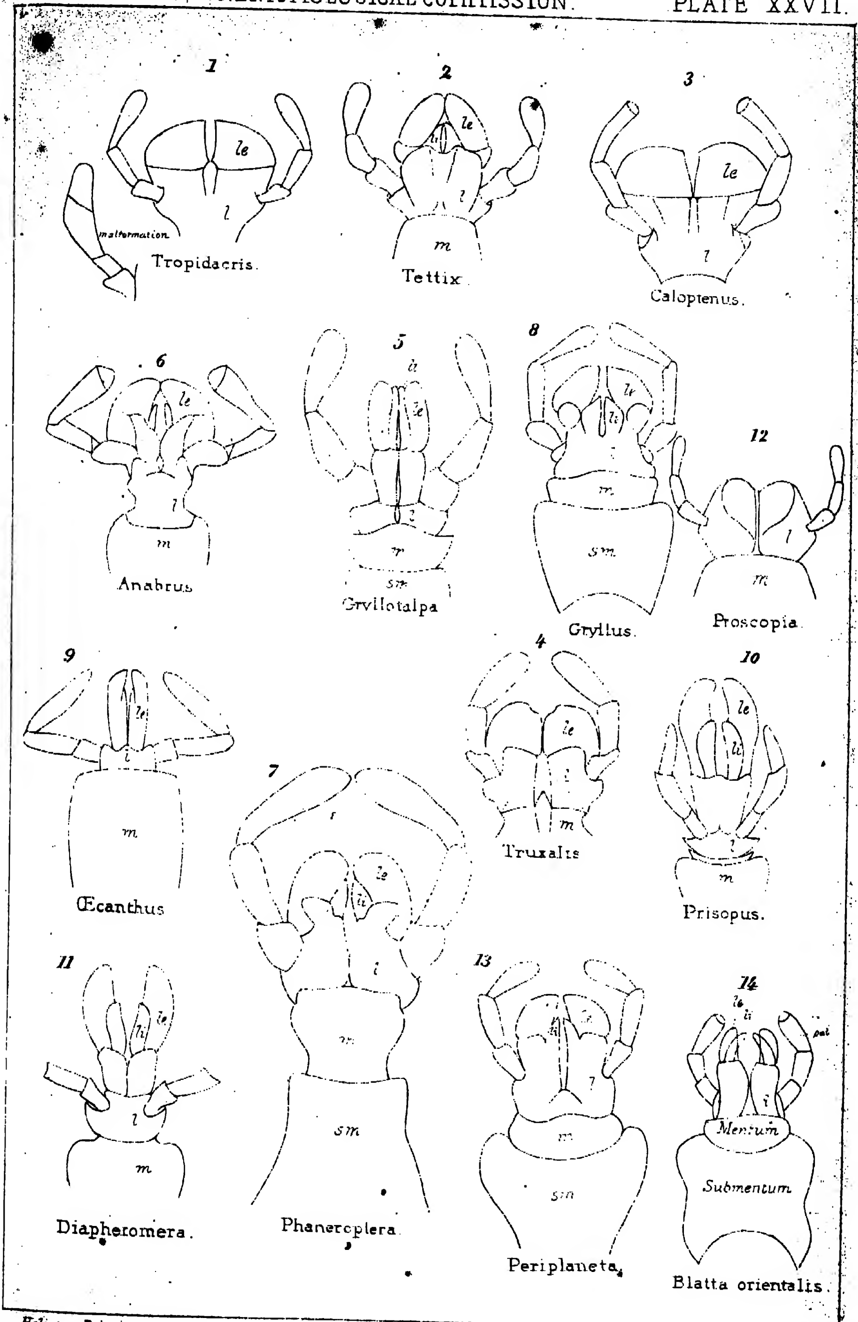
FORFICULA.



Heliotype Printing Co. Boston | Emerton, del.

ORTHOPTERA HEAD FRONT VIEW.

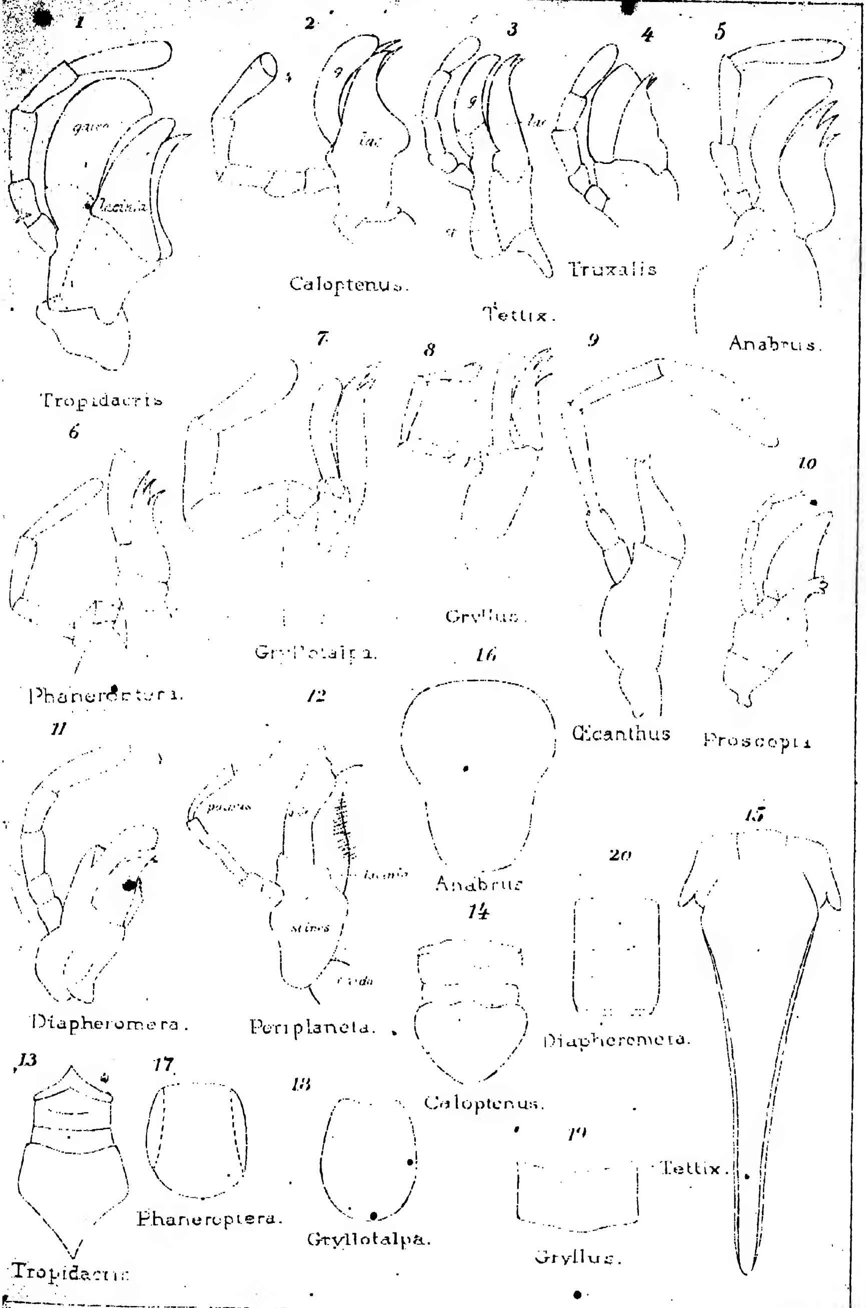

1
Conocephalus.
2
Propidacris.
3
Tettix.
4
Caloptenus.
7
Anabrus.
9
Gryllus.
10
Gryllotalpa.
8
Phaneroptera.
73
Periplaneta.
11
Œcanthus.
12
Diapheromera.
13
Prisopus.
5
Truxalis.
6
Proscopia.
14
ant.
eye
Conocephalus.
15
Propidacris.
16
Tettix.
17
Caloptenus.
19
Anabrus.
21
md
Gryllus.
22
Gryllotalpa.
20
Phaneroptera.
23
Œcanthus.
24
Diapheromera.
27
Periplaneta.
18
Truxalis.
26
md
Proscopia.
25
md
Prisopus.
Kingsley, del.



Heliotype Printing Co., Boston

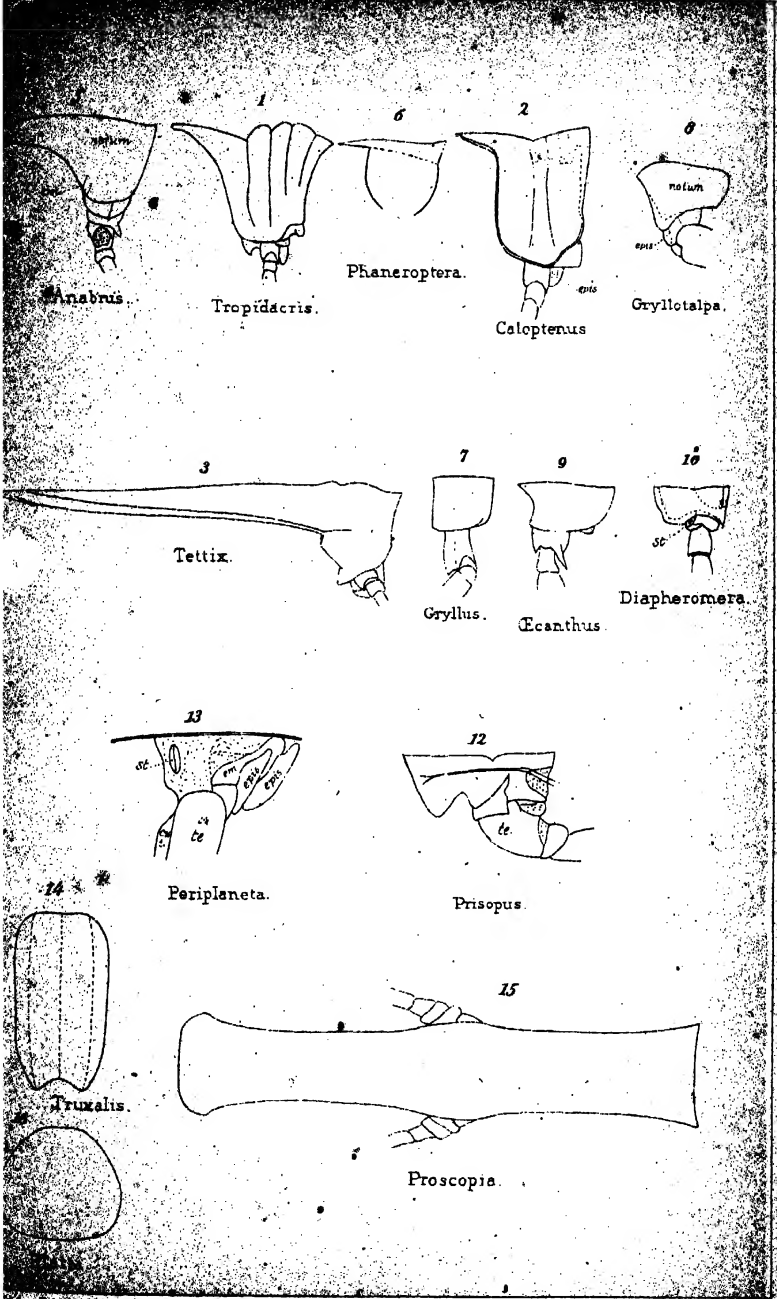
J. S. Kingsley, del.

ORTHOPTERA; SECOND MAXILLA (LABIUM).



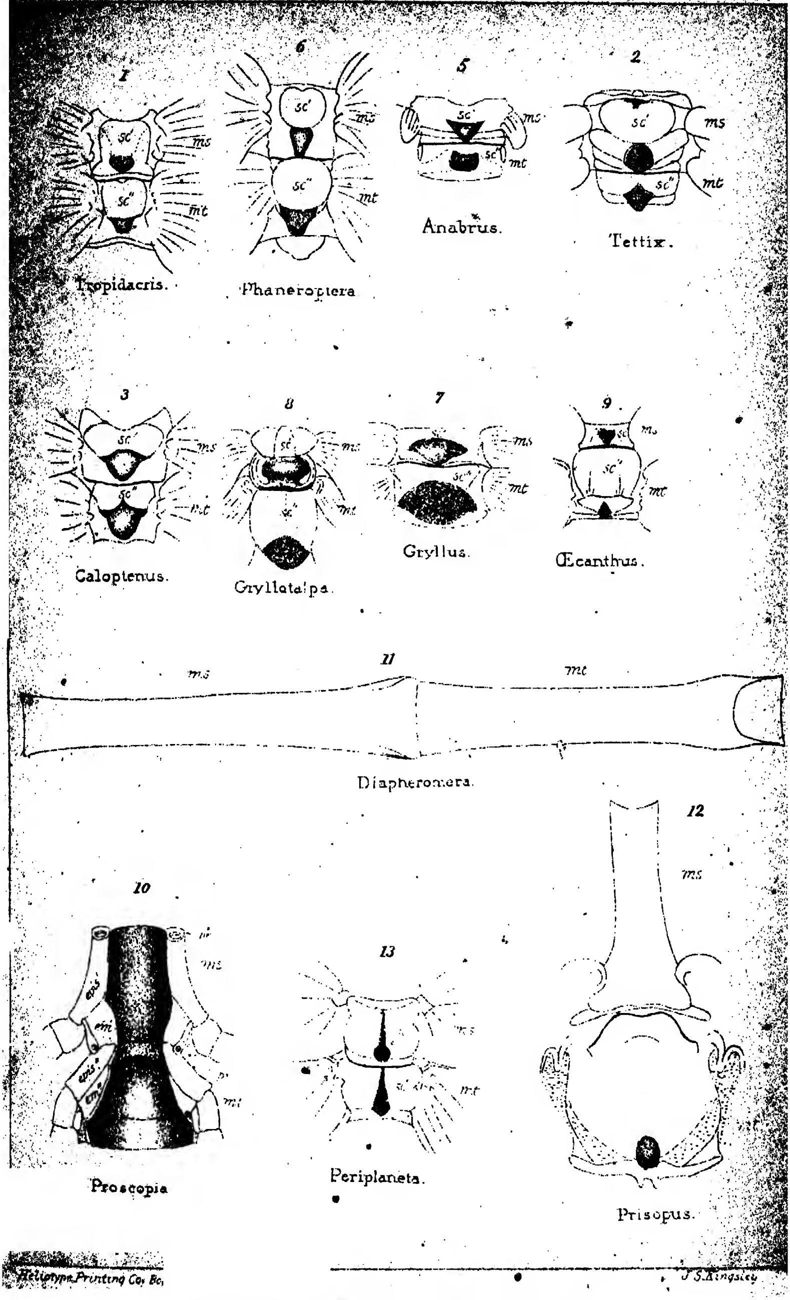
Heliotype Printing Co. Boston Kingsley, del.

ORTHOPTERA; FIG. 1–12. LEFT MAXILLA; 13–20. PRONOTUM.

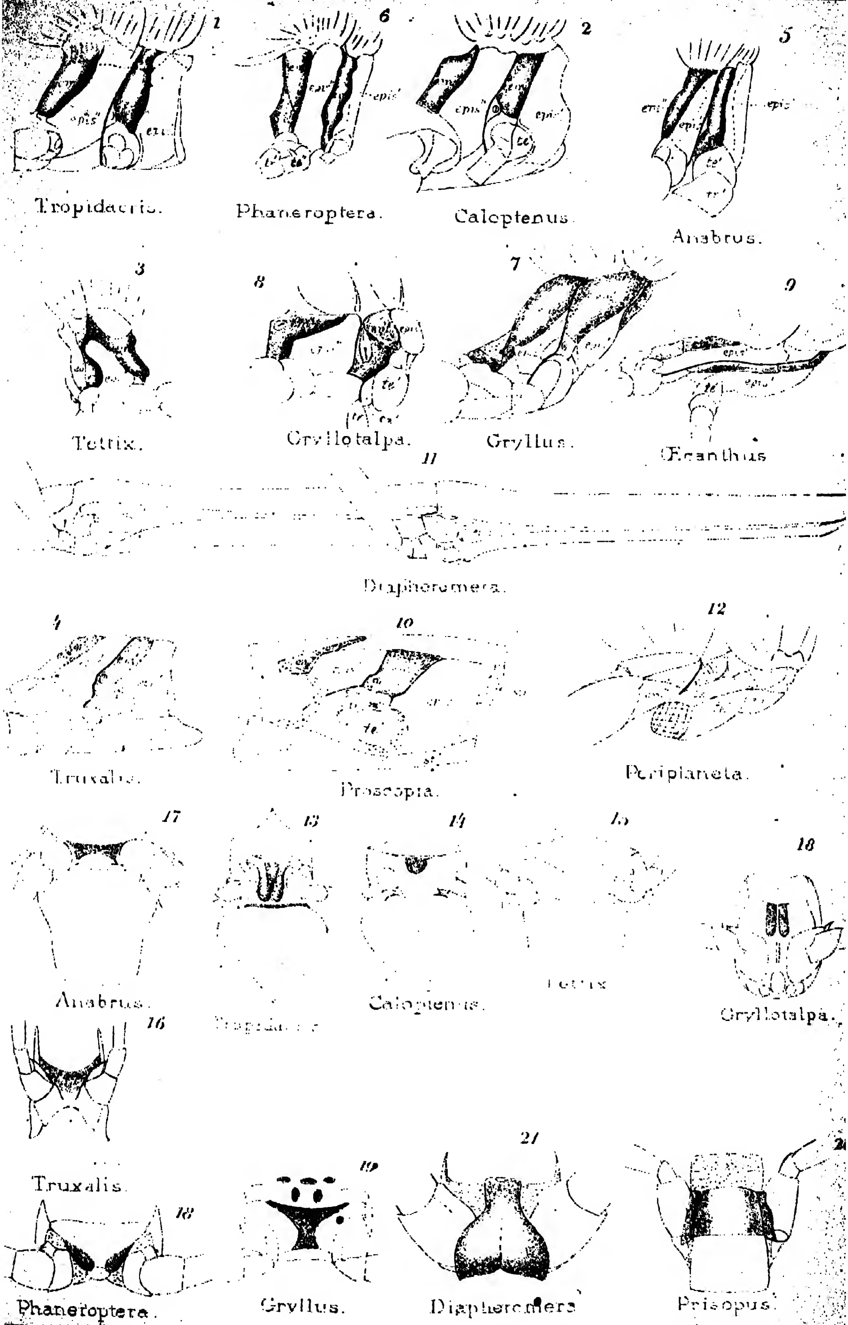


Co. Boston. J.S. Kingsley's del.

ORTHOPTERA; PROTHORAX, LATERAL AND TOP VIEW.

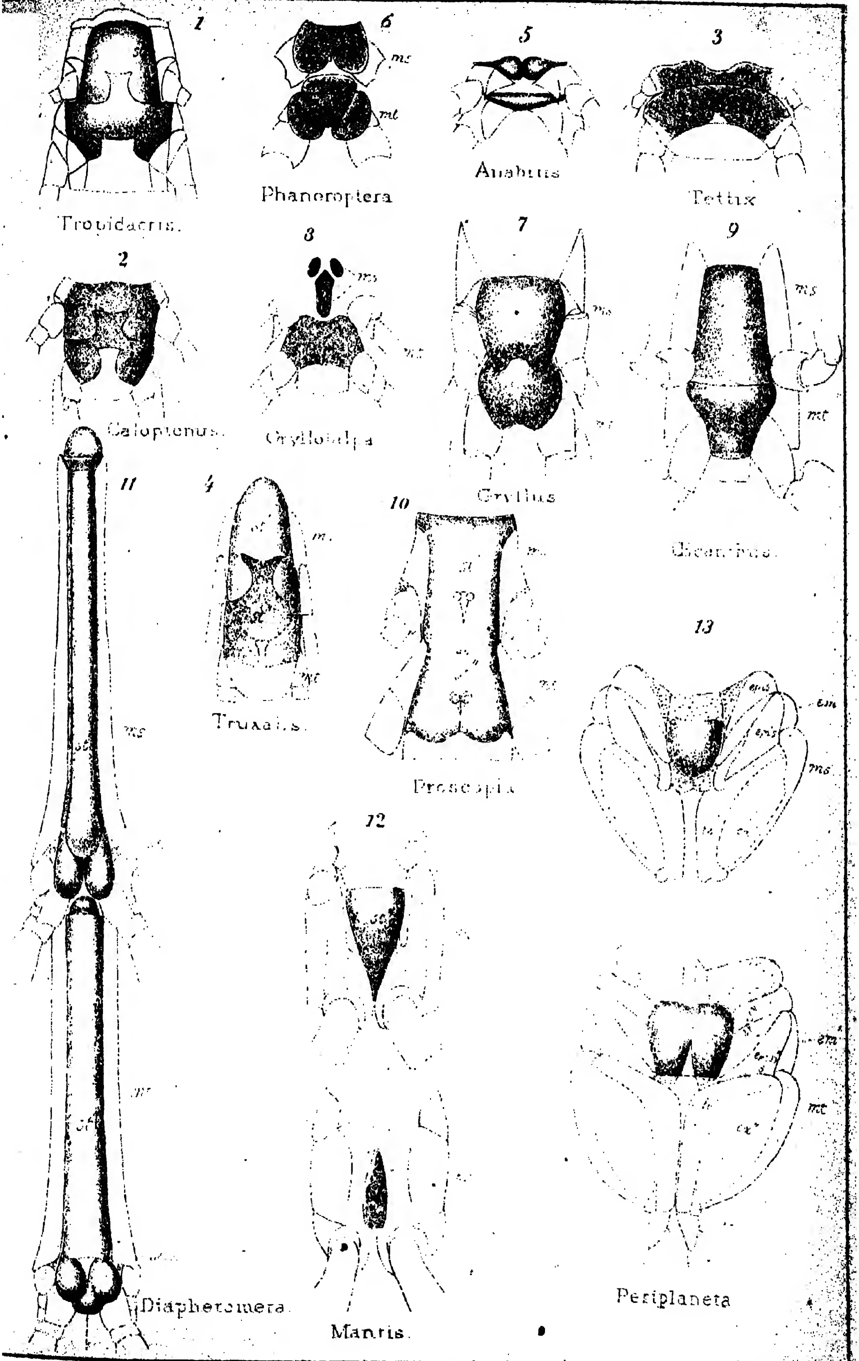


ORTHOPTERA; MESO AND METANOTUM.



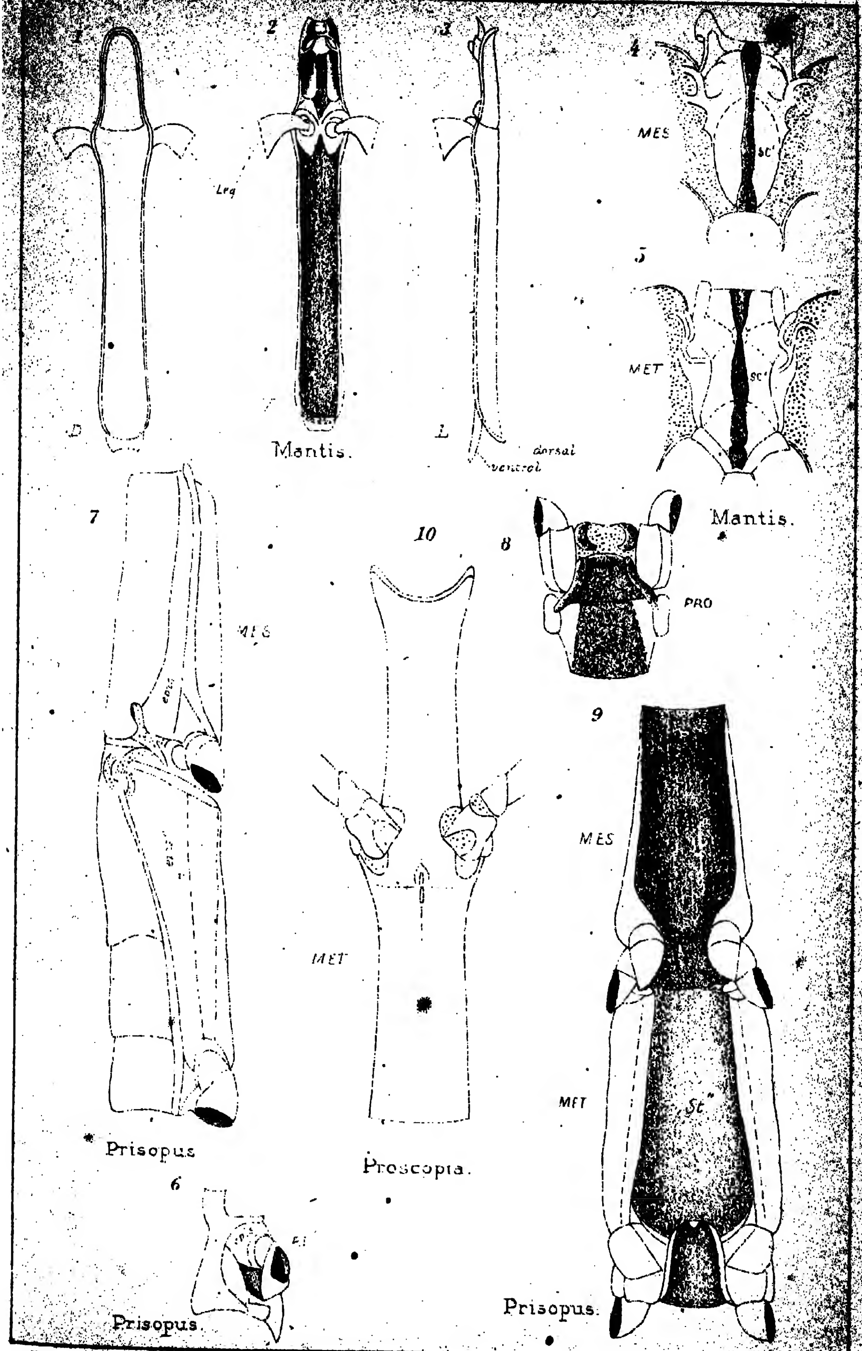
T.S.Kingsley, del.

ORTHOPTERA; 1-12, PLEURITES; 13-21, STERNUM.



Heliotype Printing Co., Boston. Gassler, del.

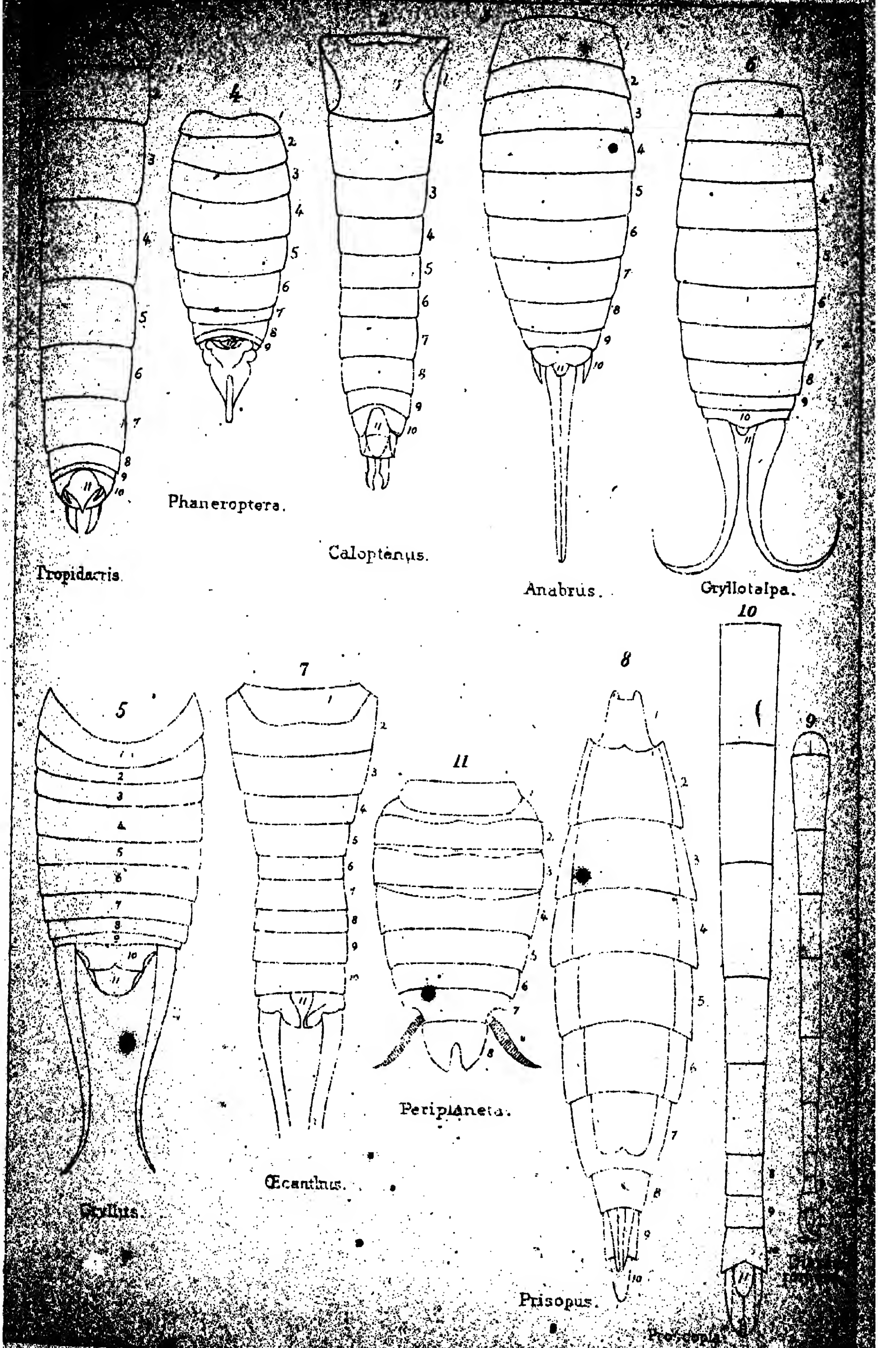
ORTHOPTERA: MESO AND METASTERNUM.



Heliotype Printing Co. Boston.

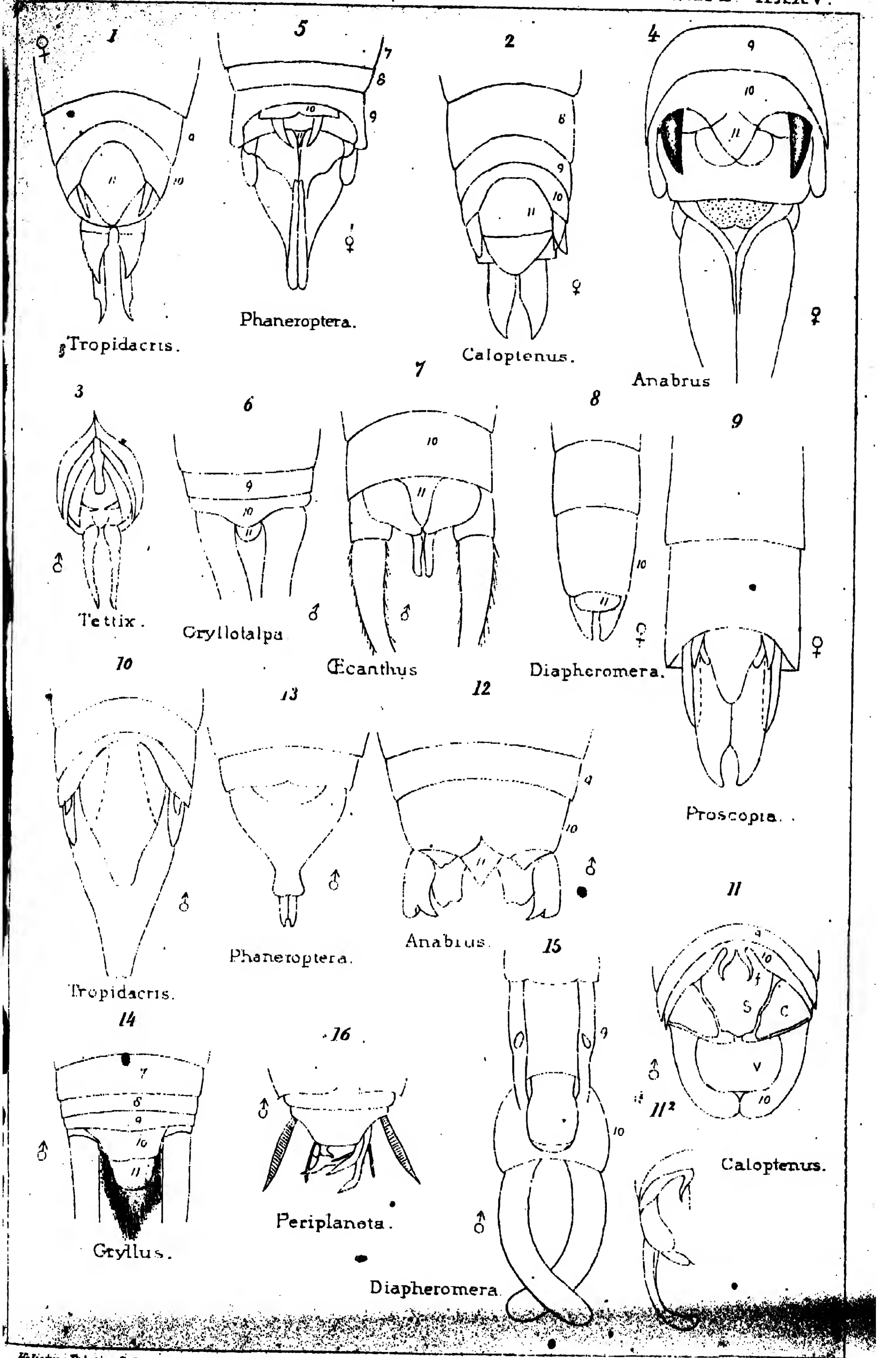
Gissler, del.

ORTHOPTERA; THORAX.



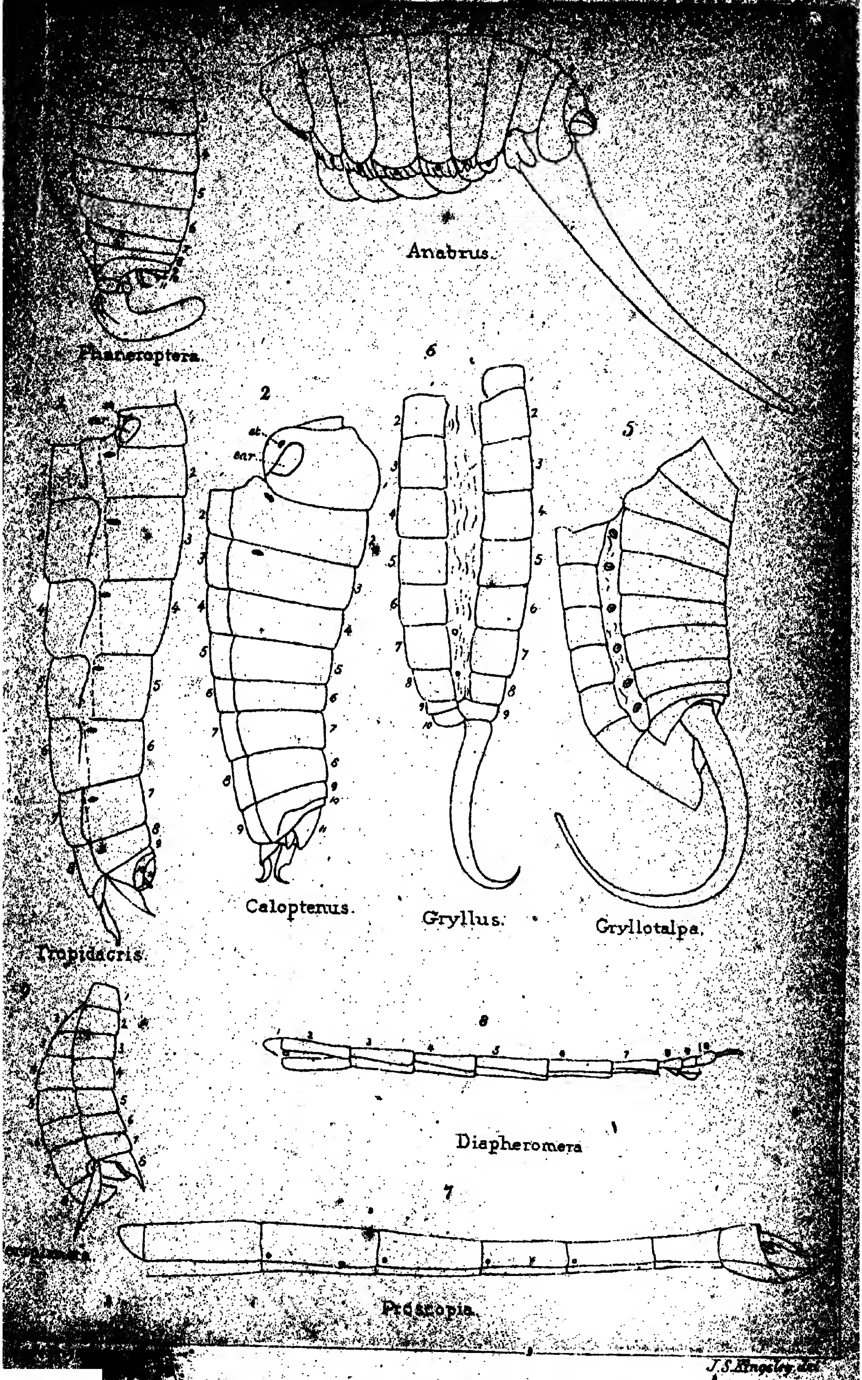
[illegible] Boston. J.S.[illegible]

ORTHOPTERA, UPPER SIDE OF ABDOMEN.

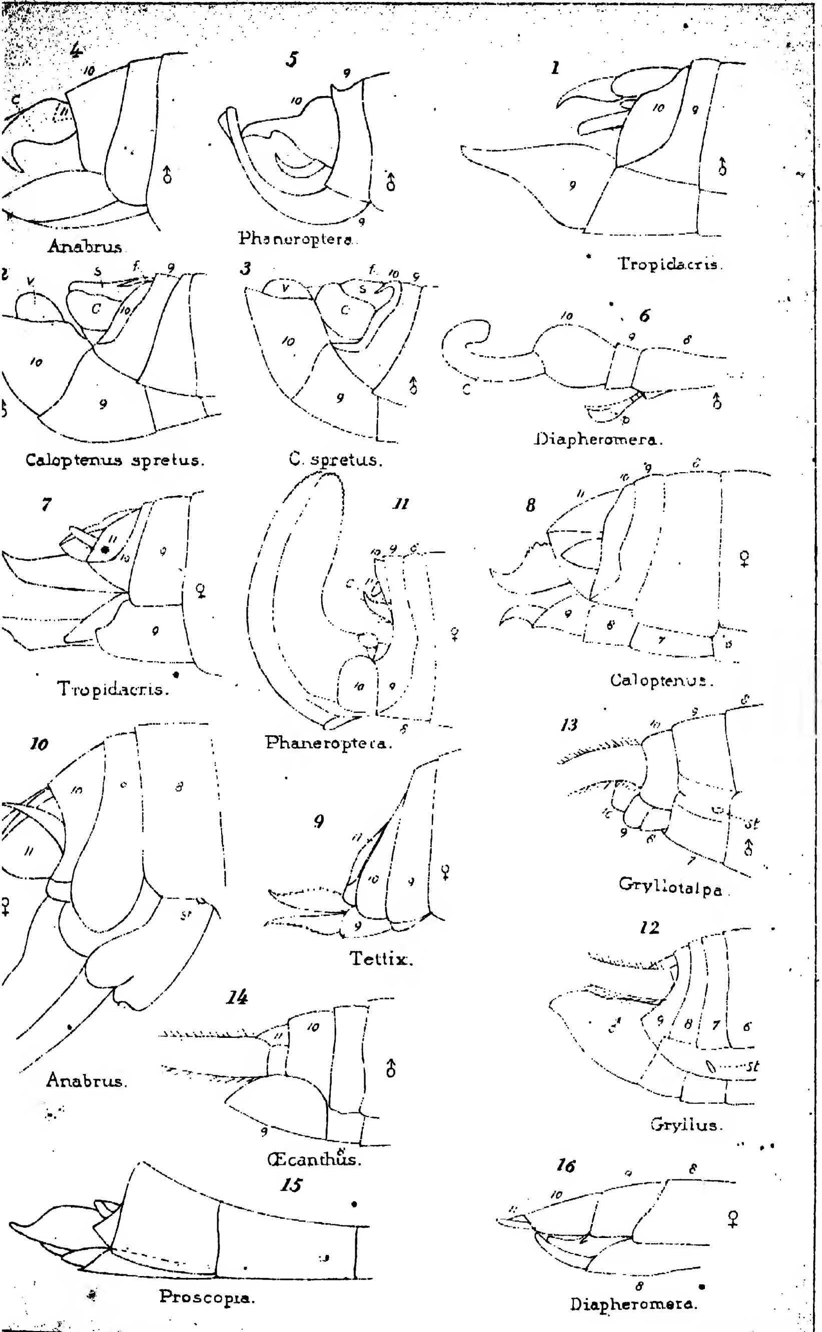


Heliotype Printing Co. Boston — J. S. Kingsley

ORTHOPTERA; END OF ABDOMEN.

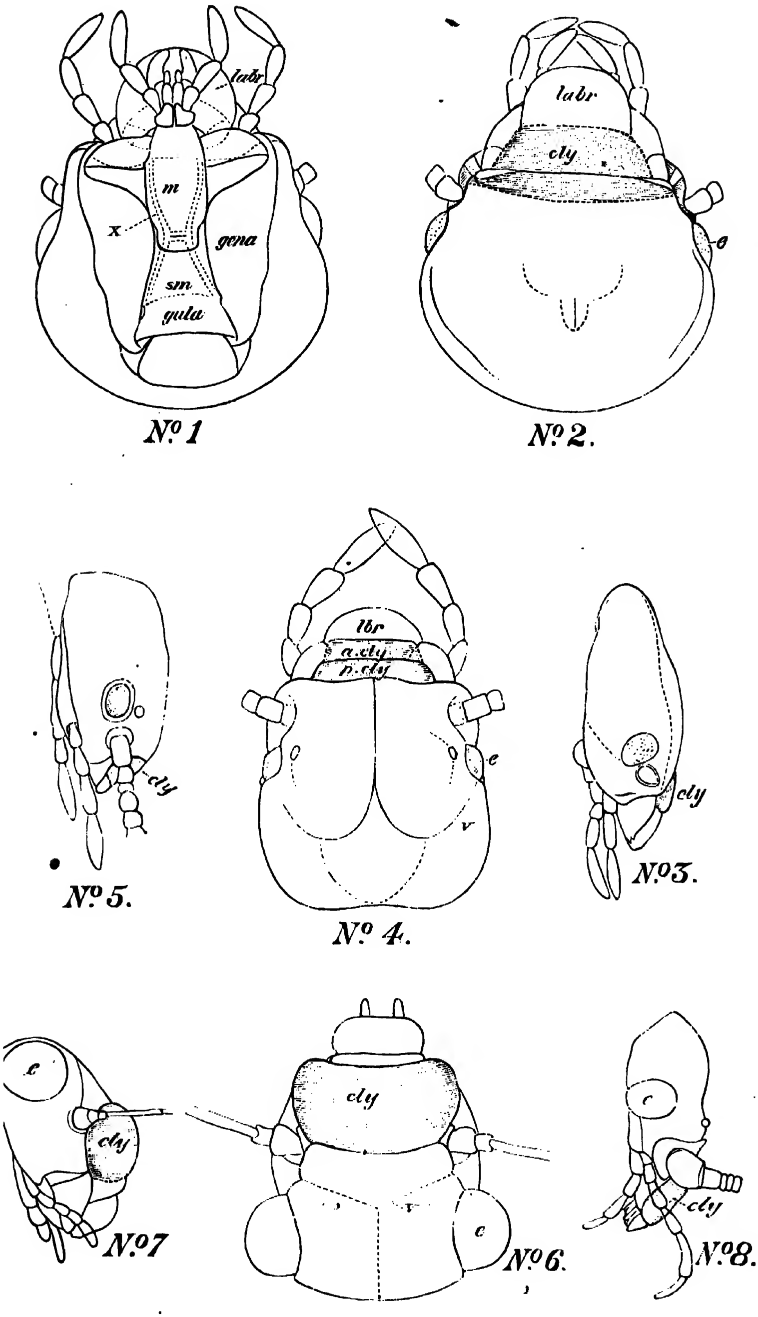


ORTHOPTERA; ABDOMEN, LATERAL VIEW

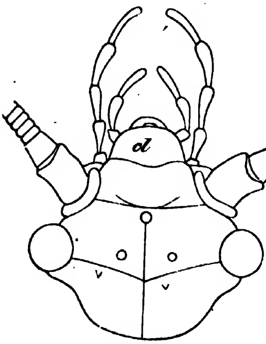


Heliotype Printing Co. Boston. J. S. Kingsley, del.

ORTHOPTERA; END OF ABDOMEN, SIDE VIEW.

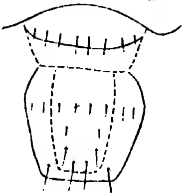


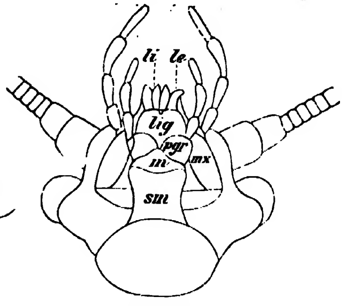
1-3. TERMOPSIS. 4, 5. TERMES. 6, 7. PSOCUS. 8. PTERONARCYS.



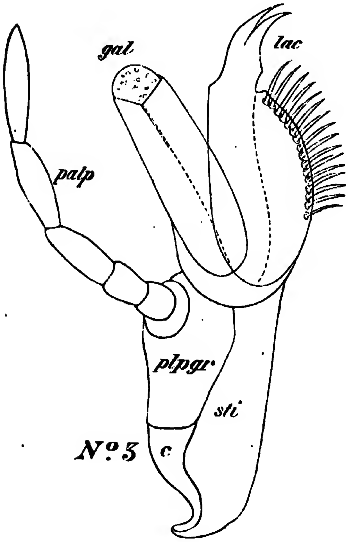
No 1

No 9 D

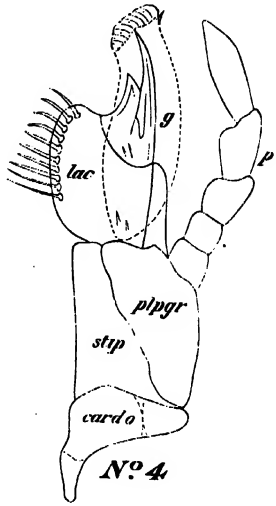




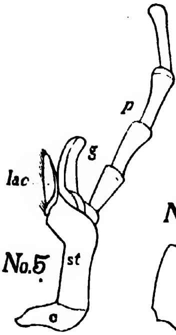
No 2



No 3

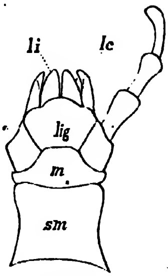


No 4

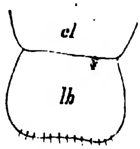


No.5

No.7

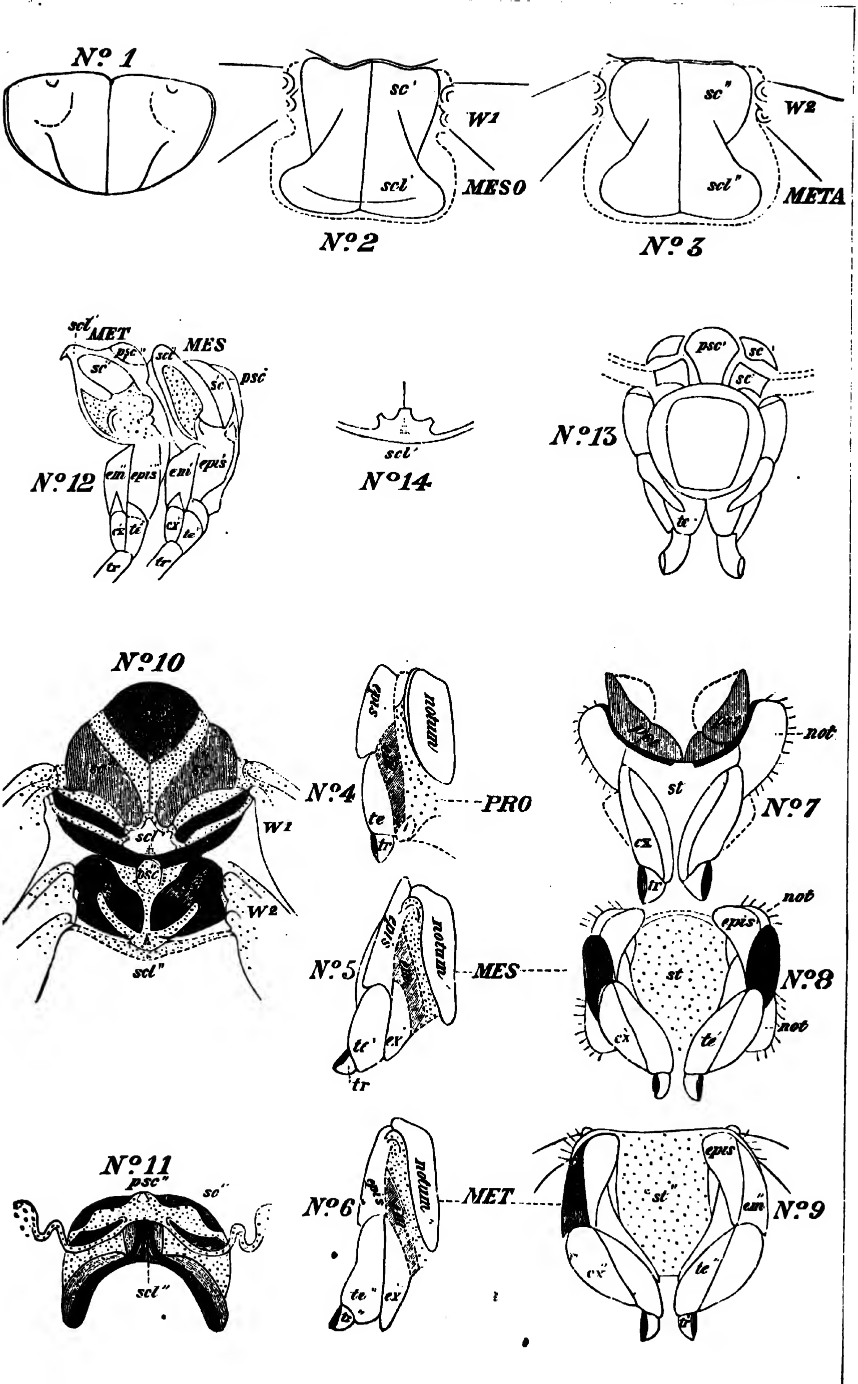


No.6



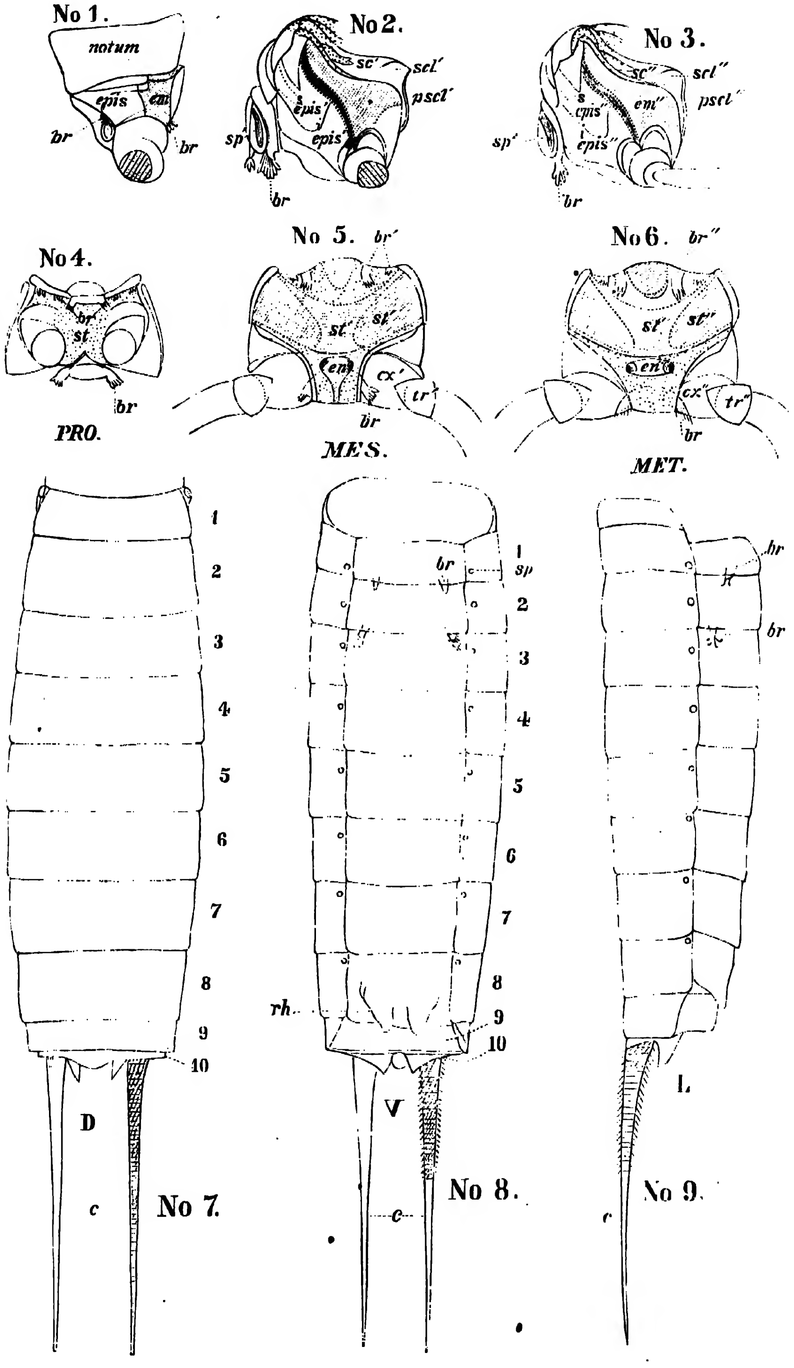
No. 8

1, 2. 5-7. PTERONARCYS. 3, 8. TERMOPSIS 4. 9. TERMES.

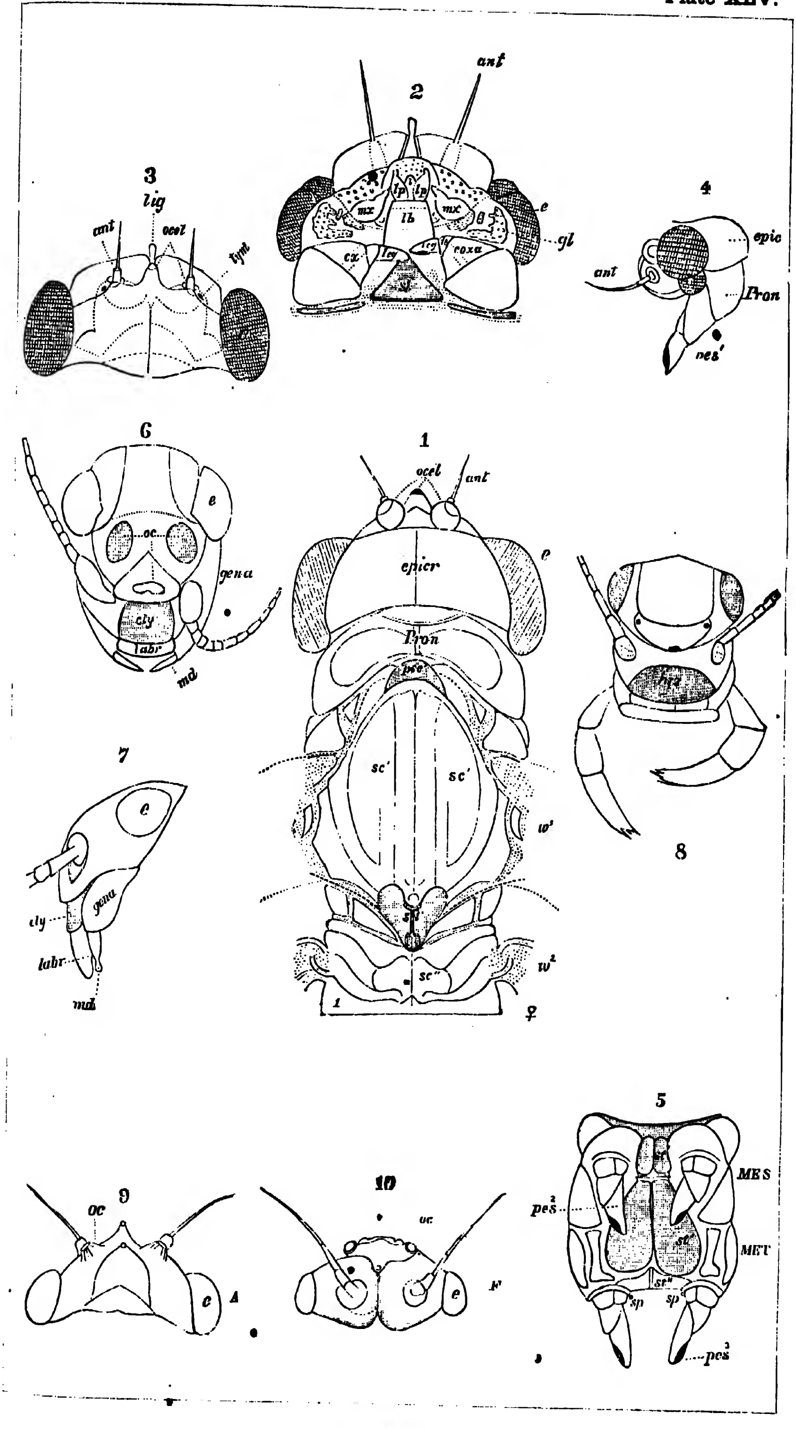


1-9. Termopsis.

10-14. Psocus.

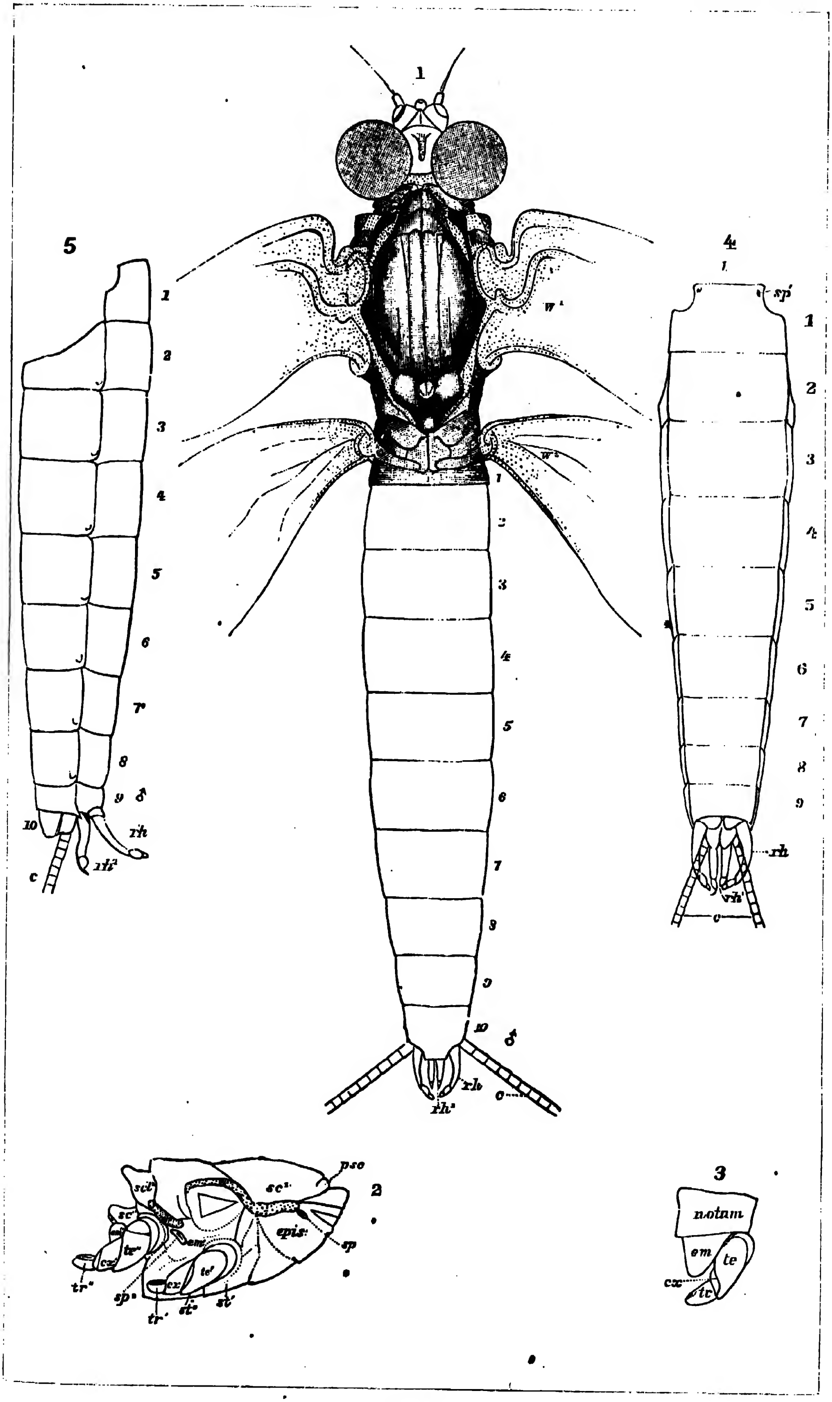


PTERONARCYS CALIFORNICA.

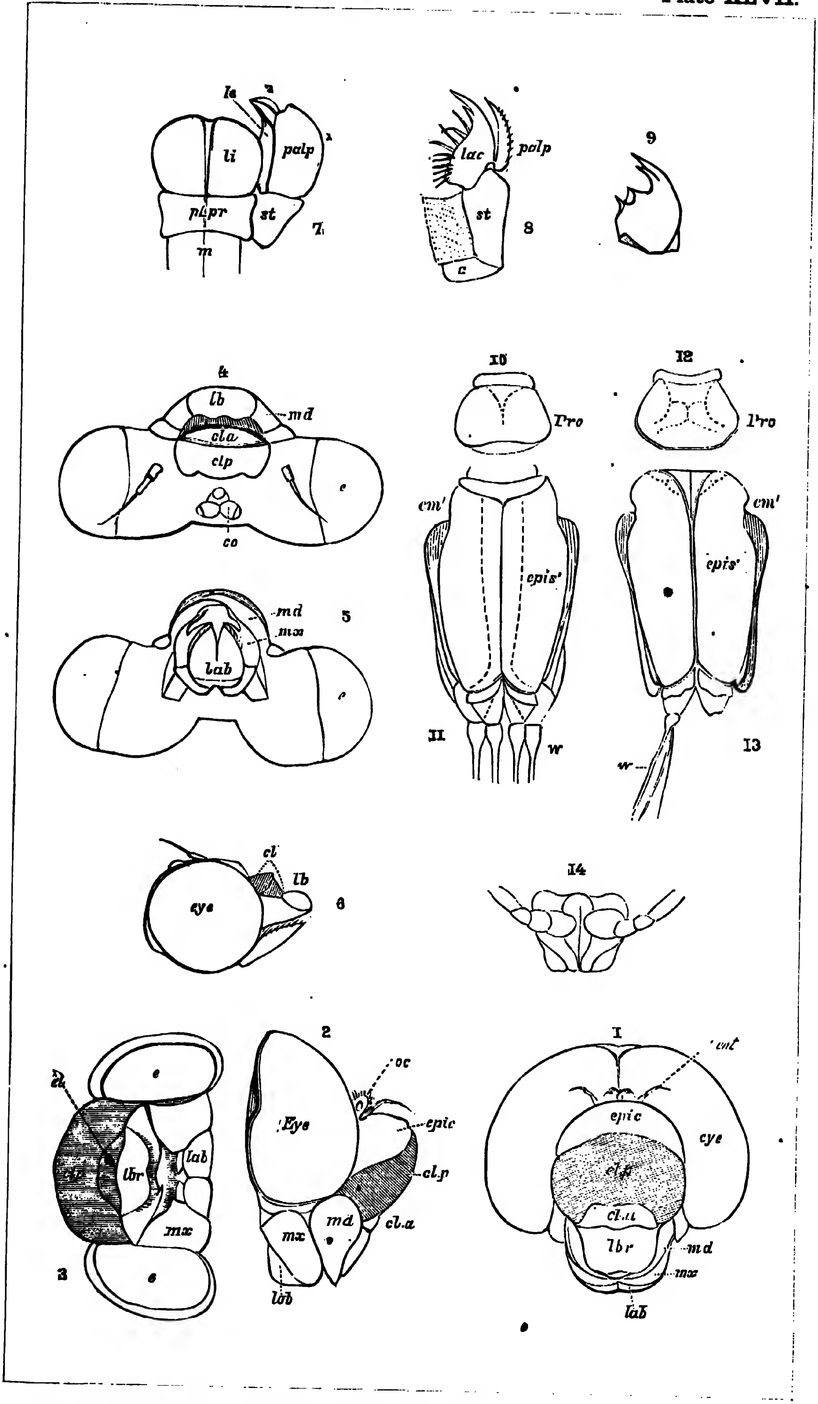


1
2
3
4
5
6
7
8
9
10
ant
ocel
lig
epicr
Pron
sc'
sc''
w'
w²
e
gl
lp
lb
mx
cx
coxa
st
epic
pes'
gena
oc
cly
labr
md
MES
MET
sp

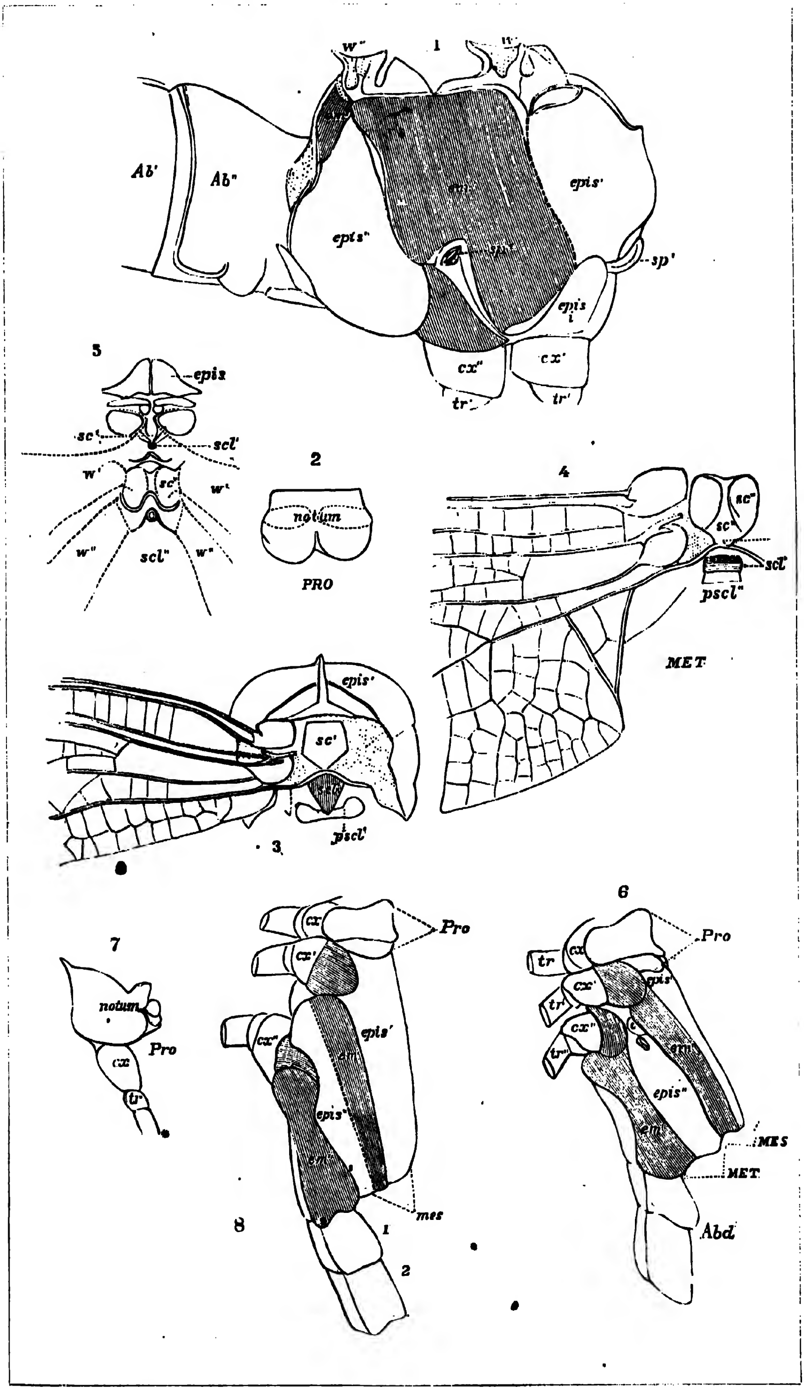
EPHEMERA.



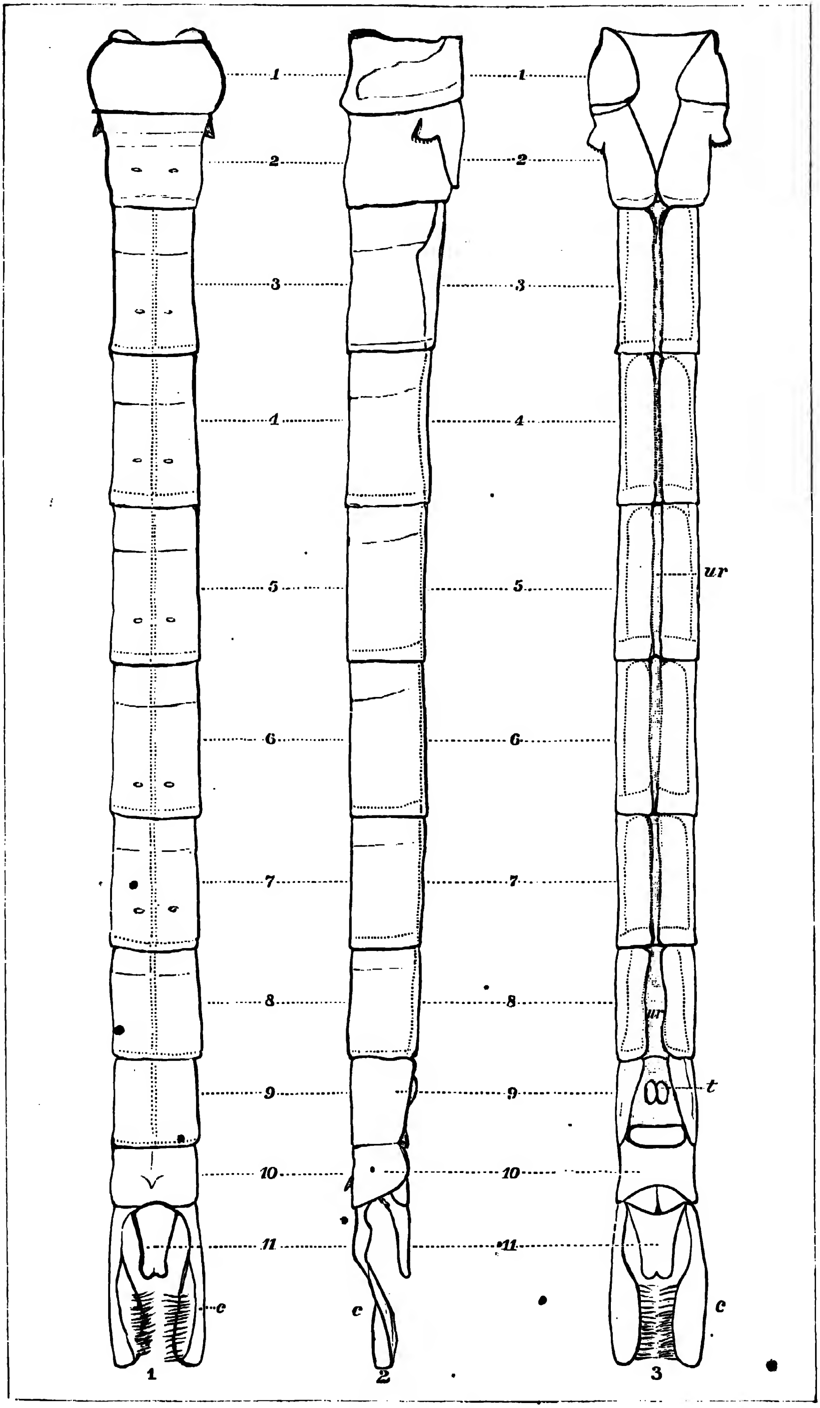
EPHEMERA.



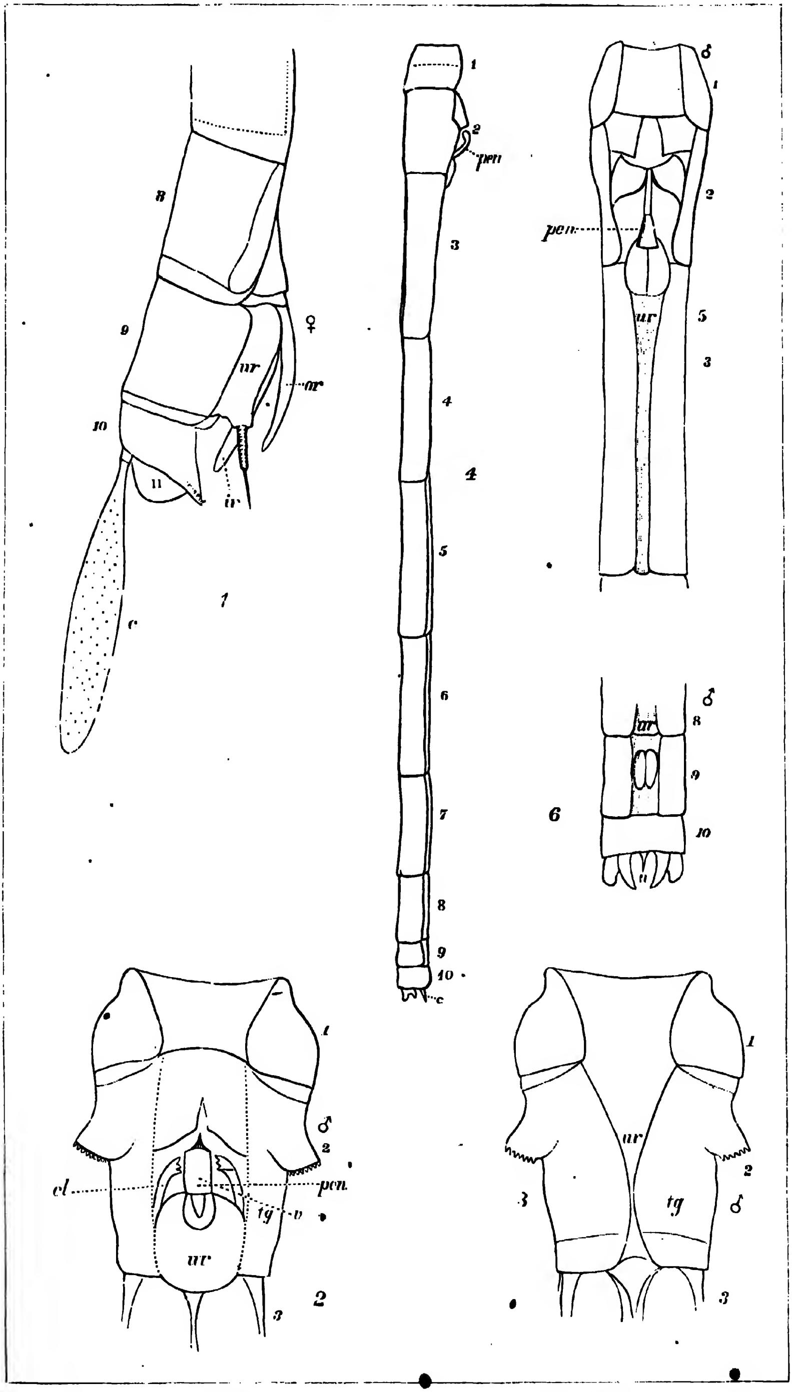
1–3, 7–9. ÆSCHNA HEROS. 4–6, 10, 11. AGRION VERTICALE? 12, 13. CALOPTERYX MACULATA.



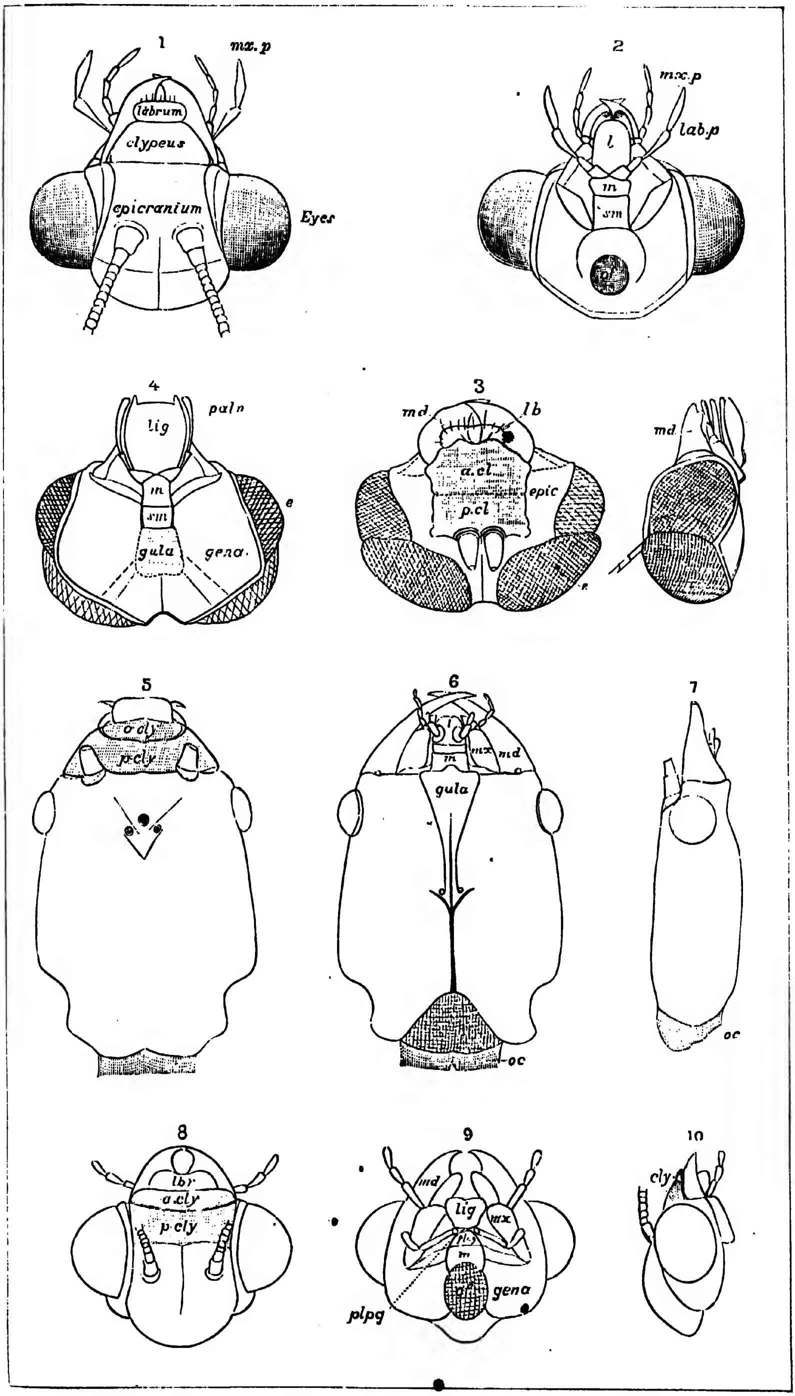
1–4. Æschna. 5, 6. Calopteryx. 7, 8. Agrion.



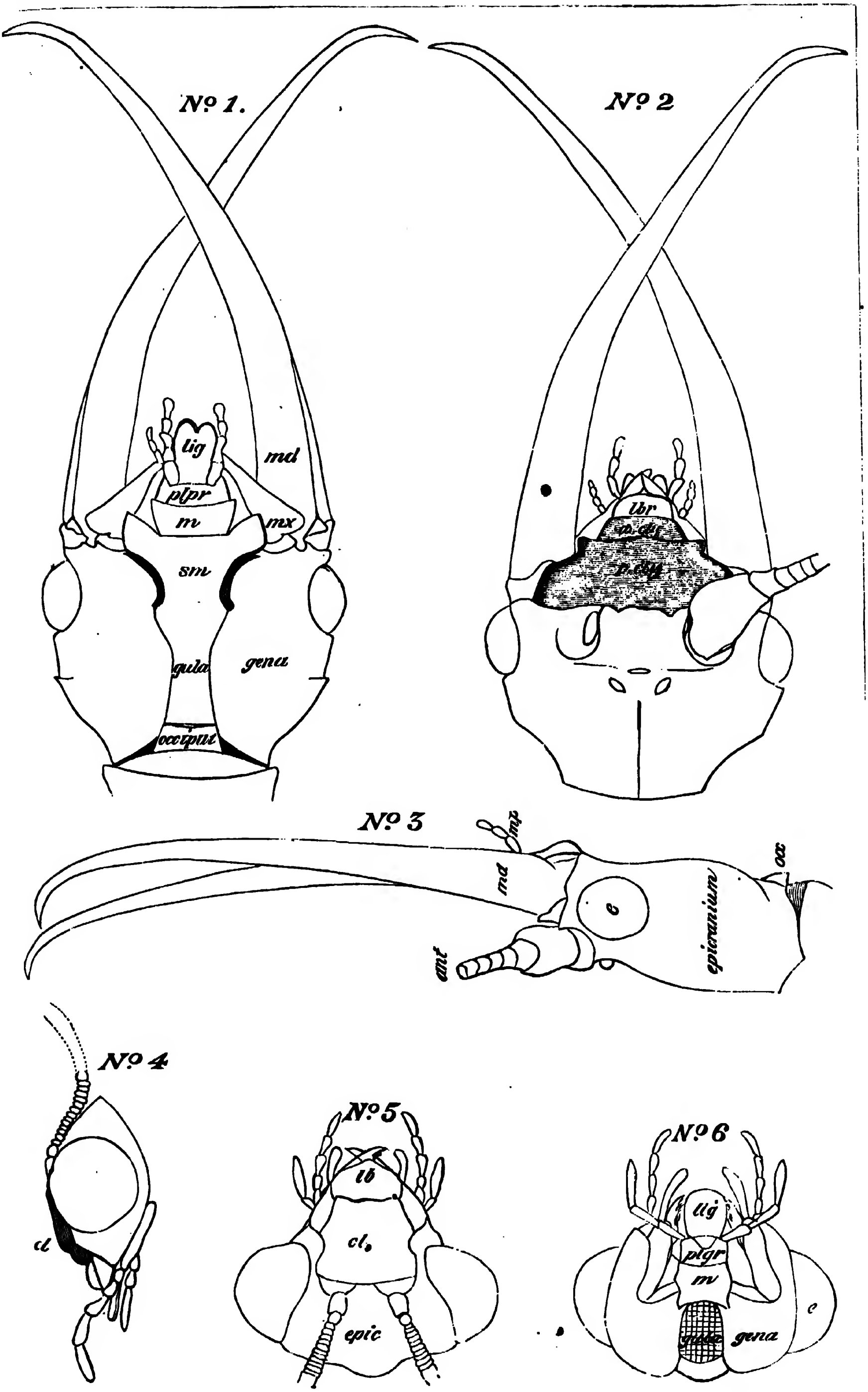
ABDOMEN OF ÆSCHNA HEROS.



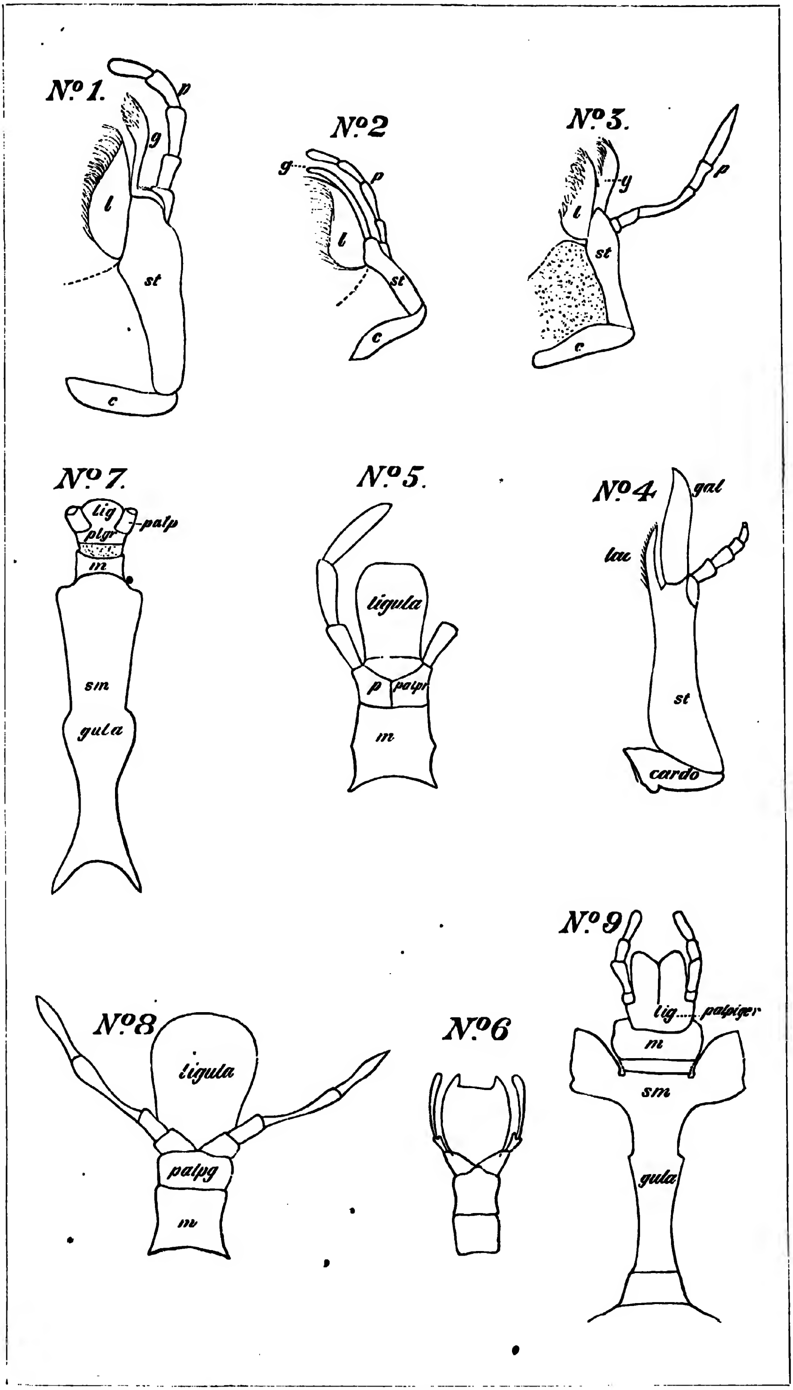
1–3. ÆSCHNA. 4–6. AGRION.



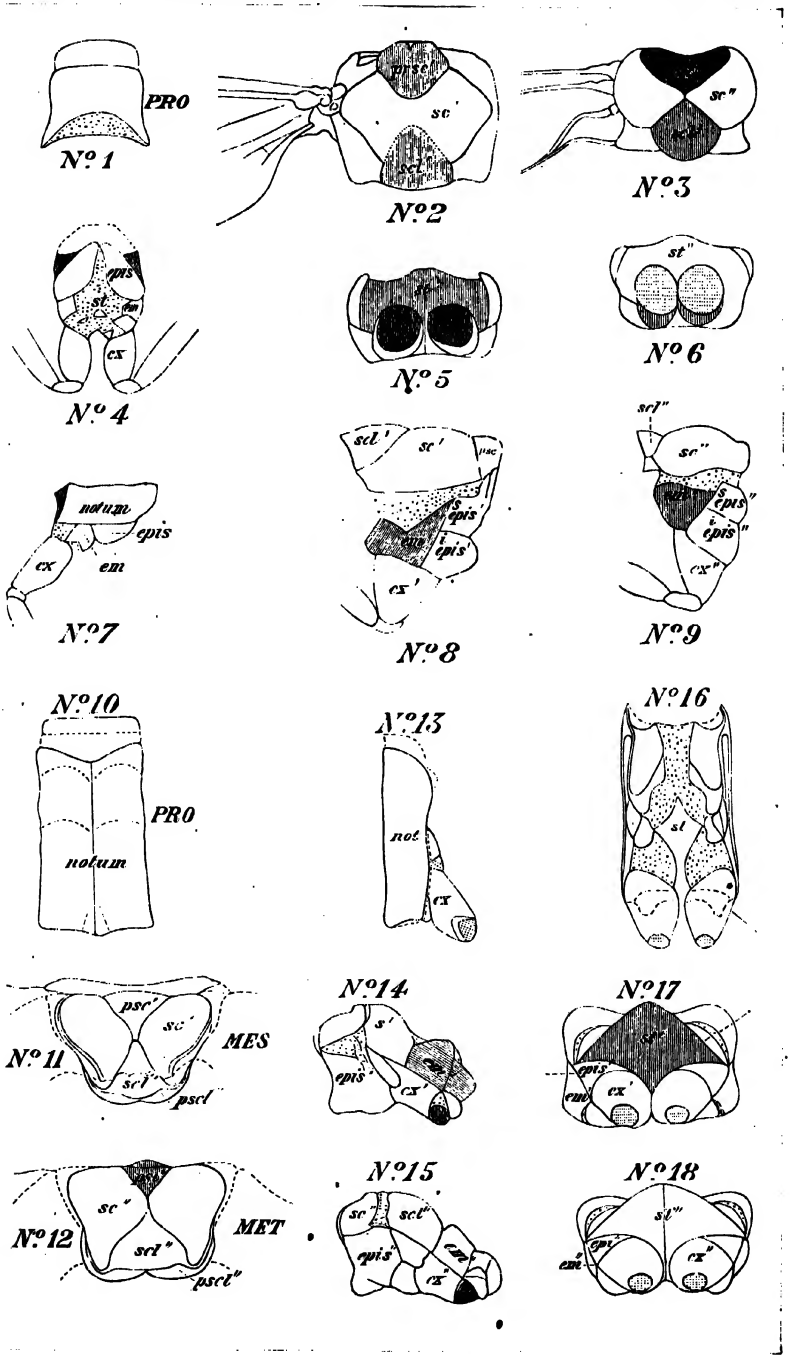
1, 2. Myrmeleon. 3, 4. Ascalaphus. 5–7. Raphidia. 8–10. Polystœchotes.



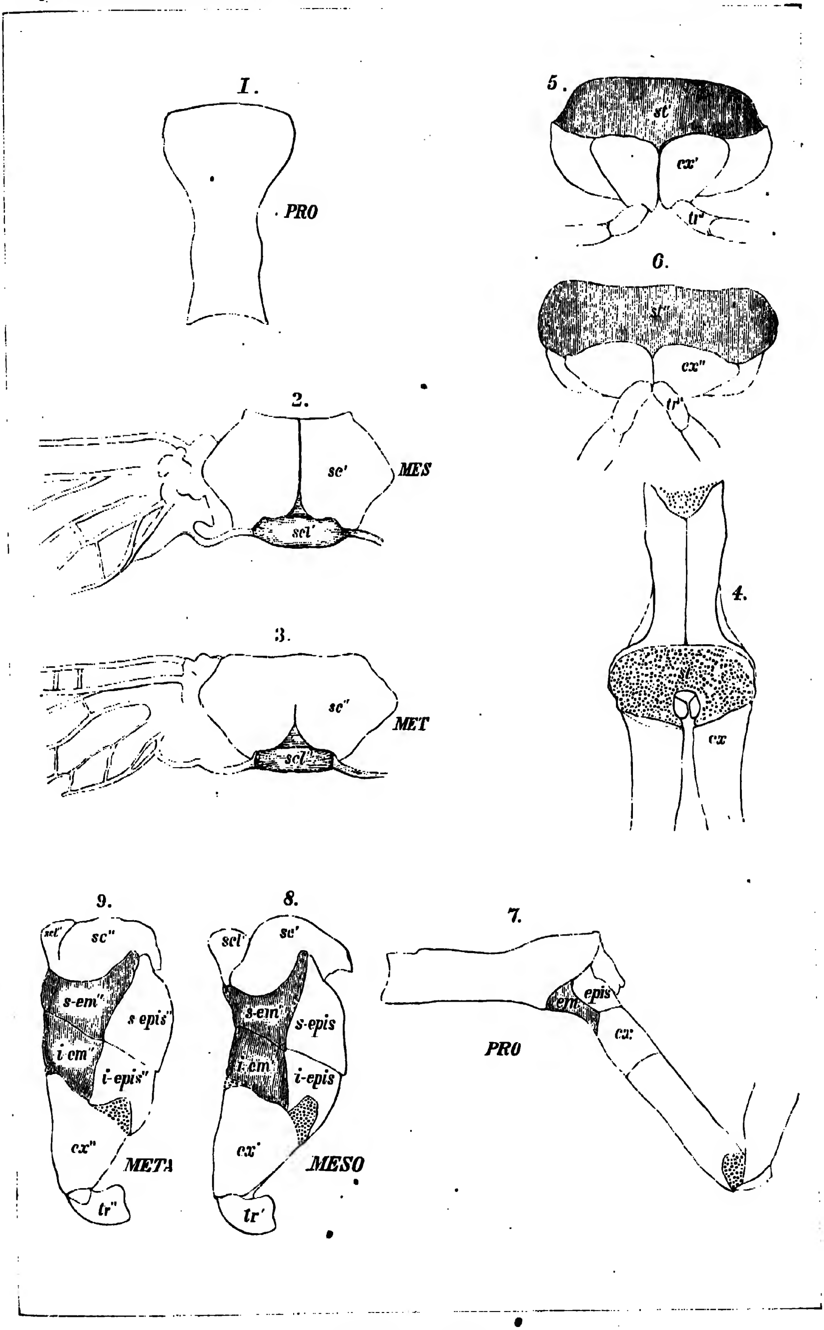
1–3. CORYDALUS. 4–6. MANTISPA.



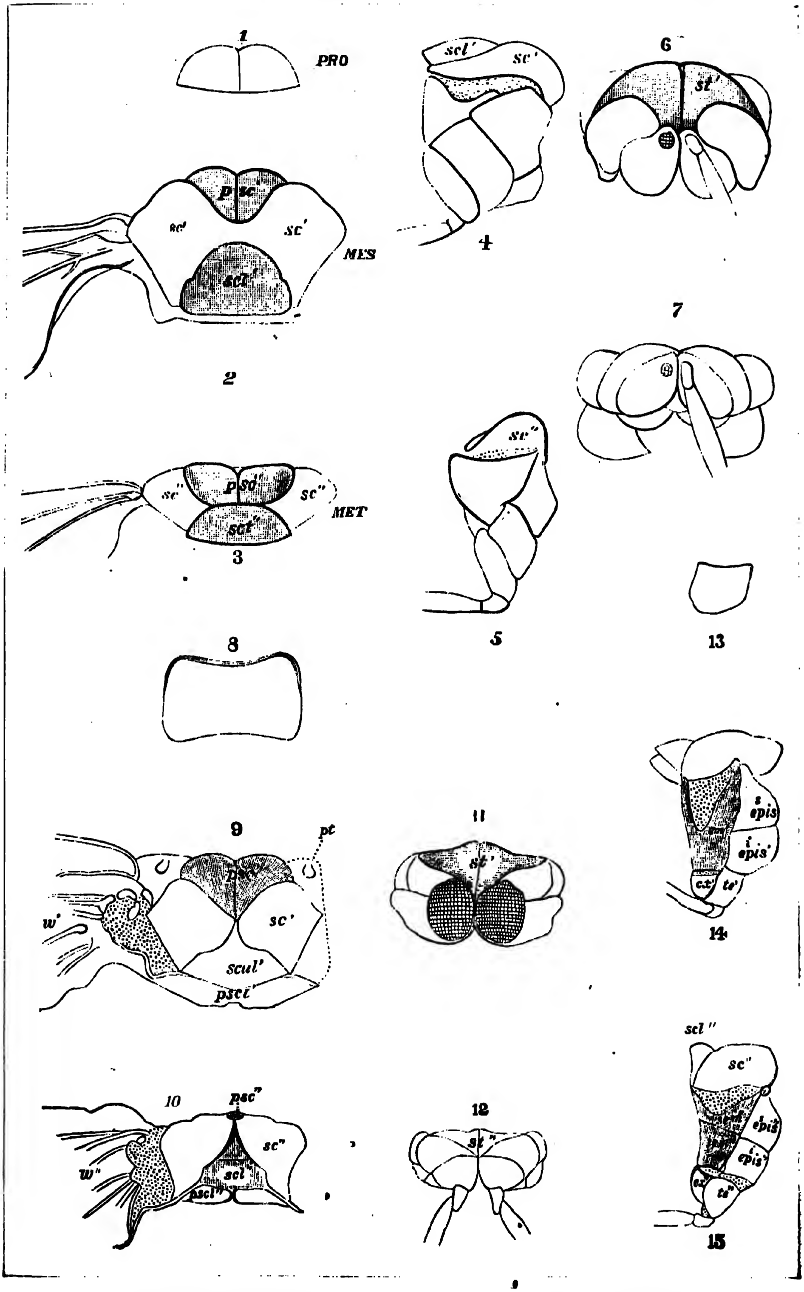
1, 5. Mantispa. 2, 6. Ascalaphus. 3, 8. Myrmeleon. 4, 9. Corydalus. 7. Raphidia.



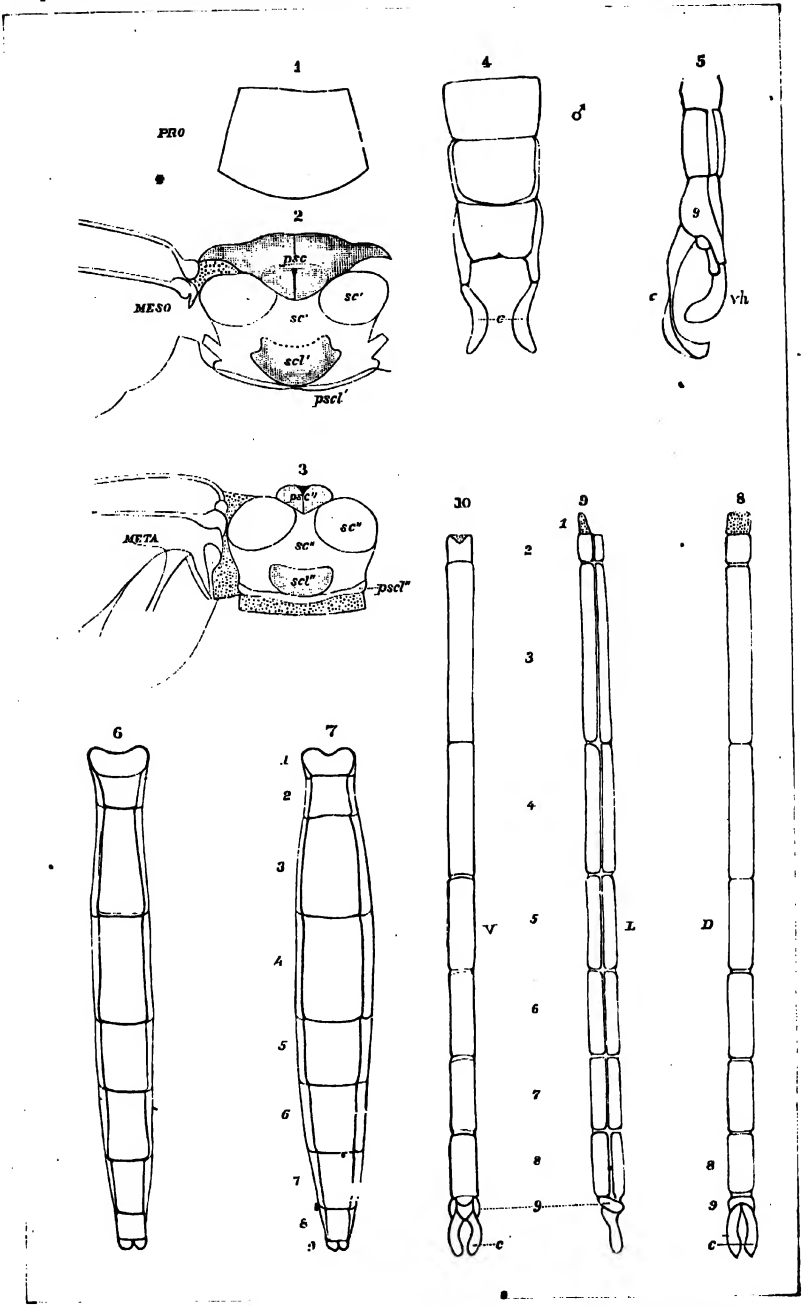
1-9. Myrmeleon. 10-18. Raphidia.



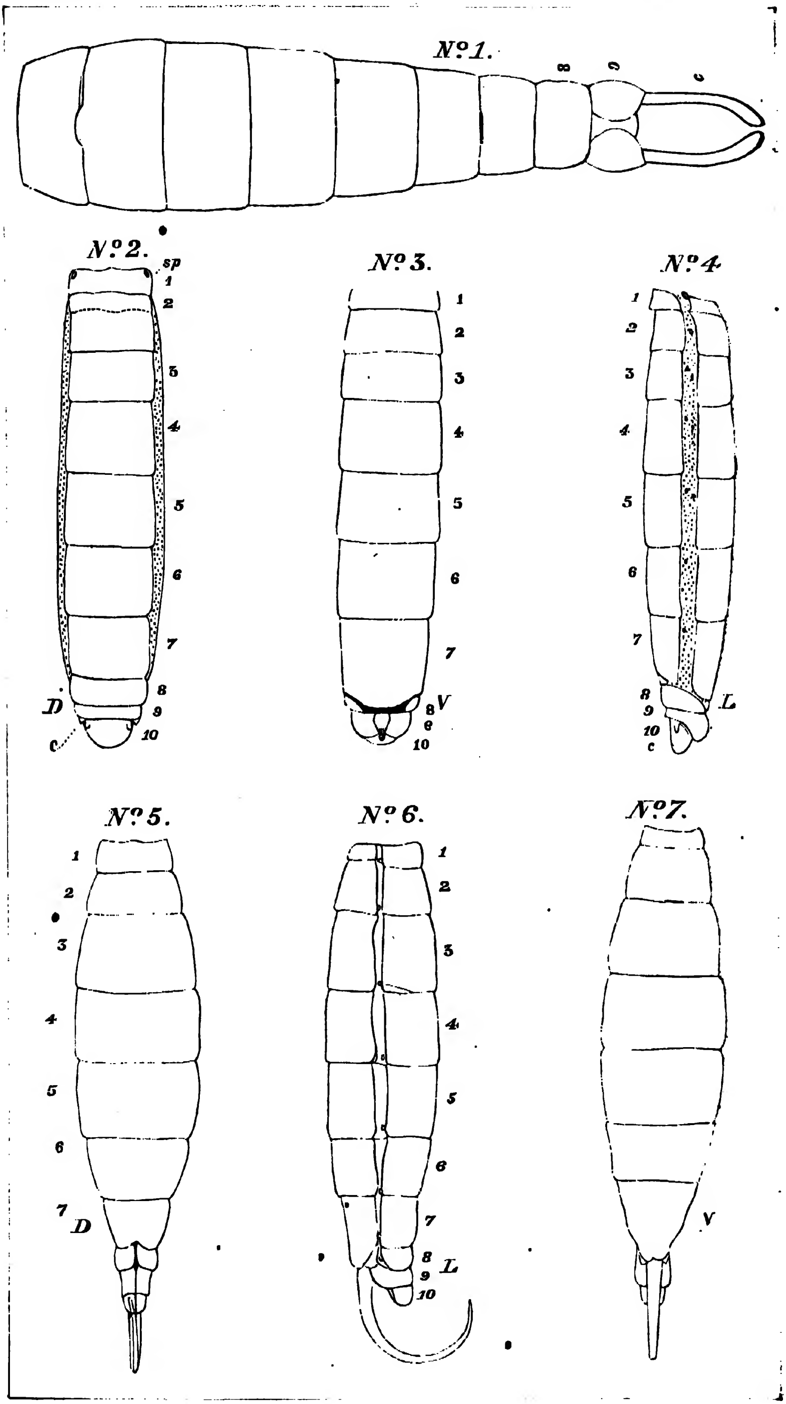
MANTISPA BRUNNEA.



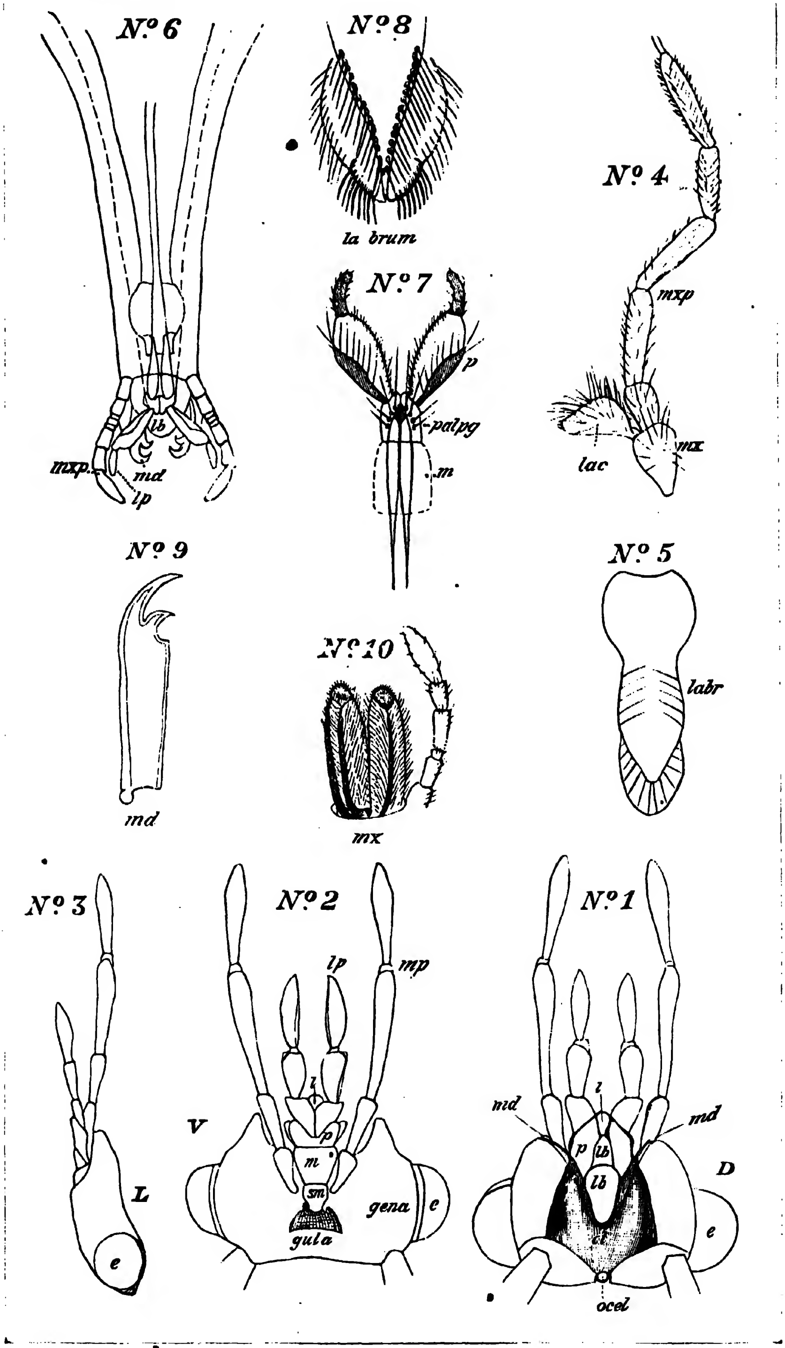
1-7. Thorax of Ascalaphus. 8-15. Polystoechotes.



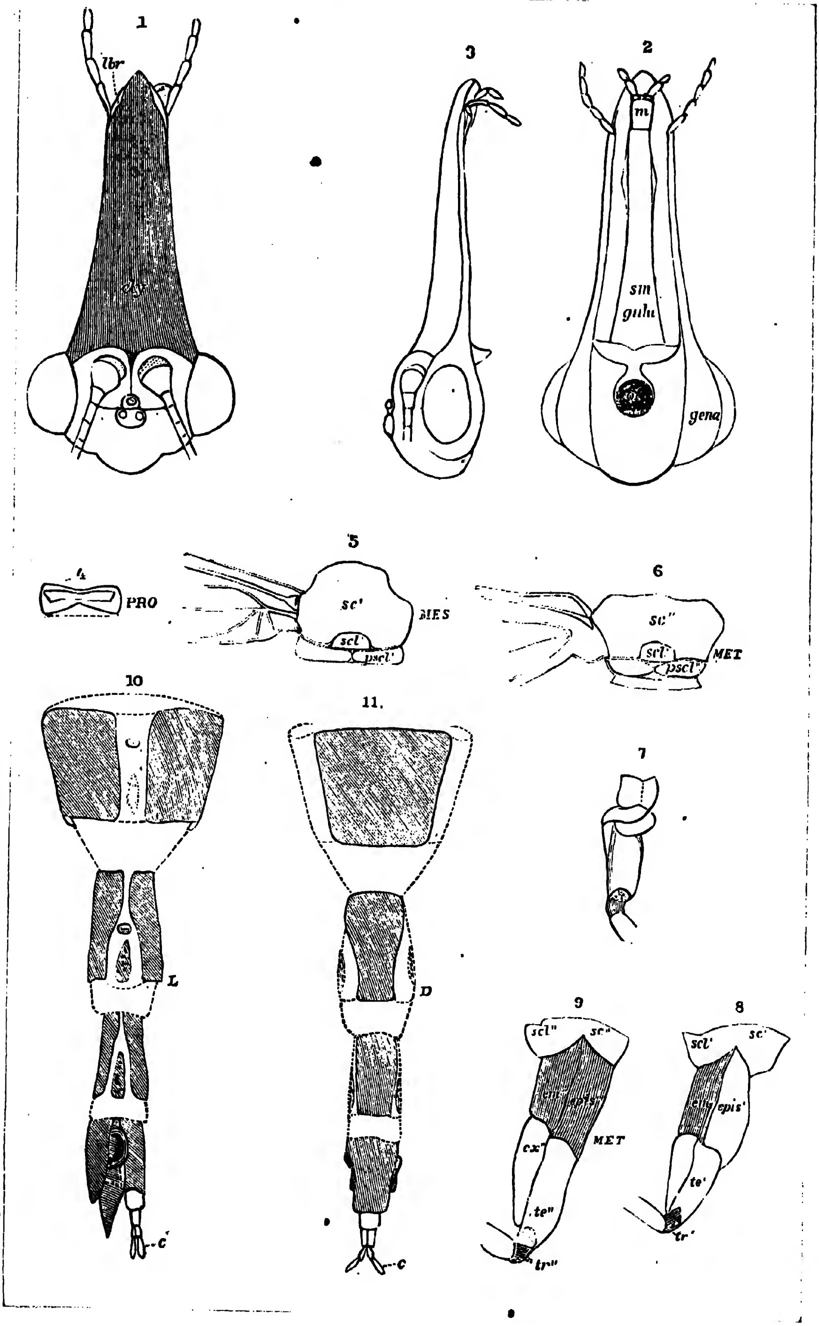
1–3. PTERONARCYS. 4, 5. CORYDALUS. 6, 7. ASCALAPHUS. 8–10. MYRMELEON.



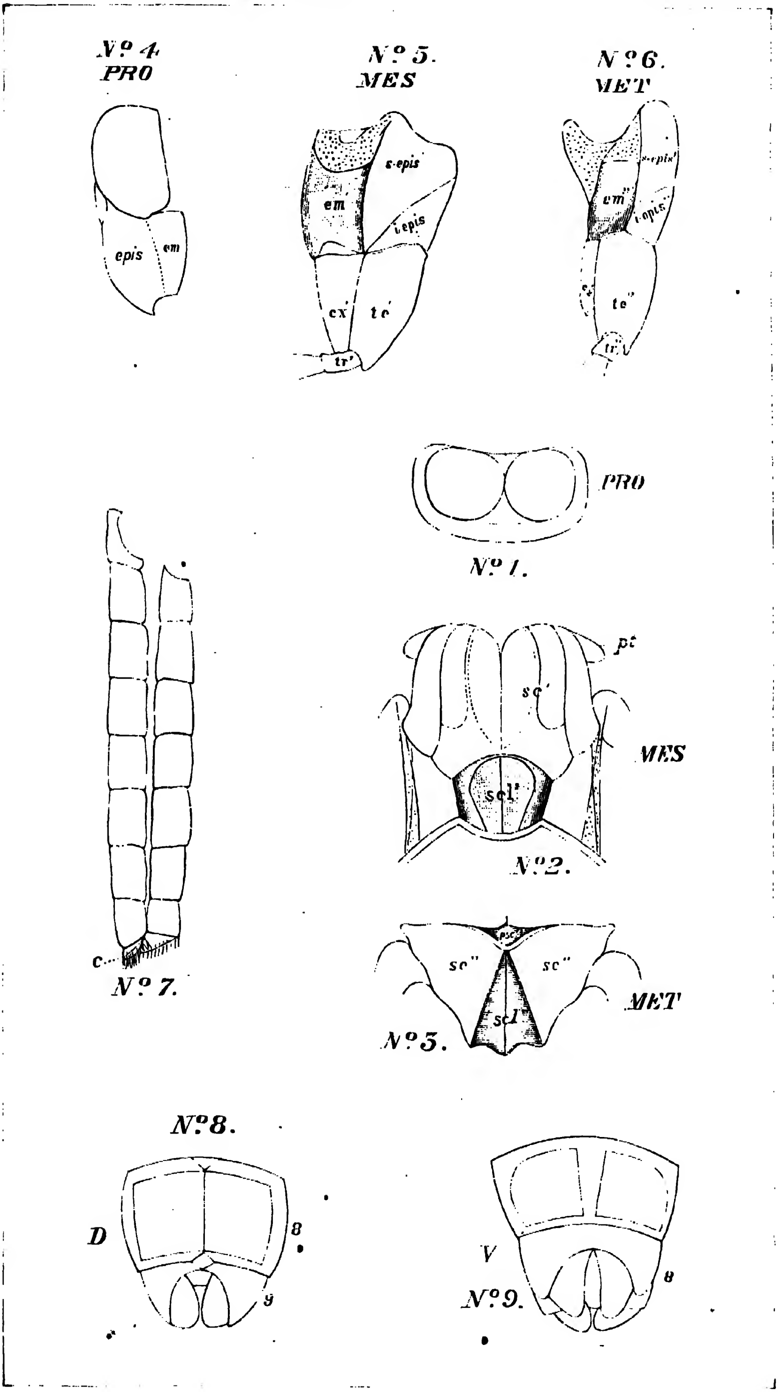
1. Corydalus. 2–4. Polystoechotes. 5–7. Raphidia.



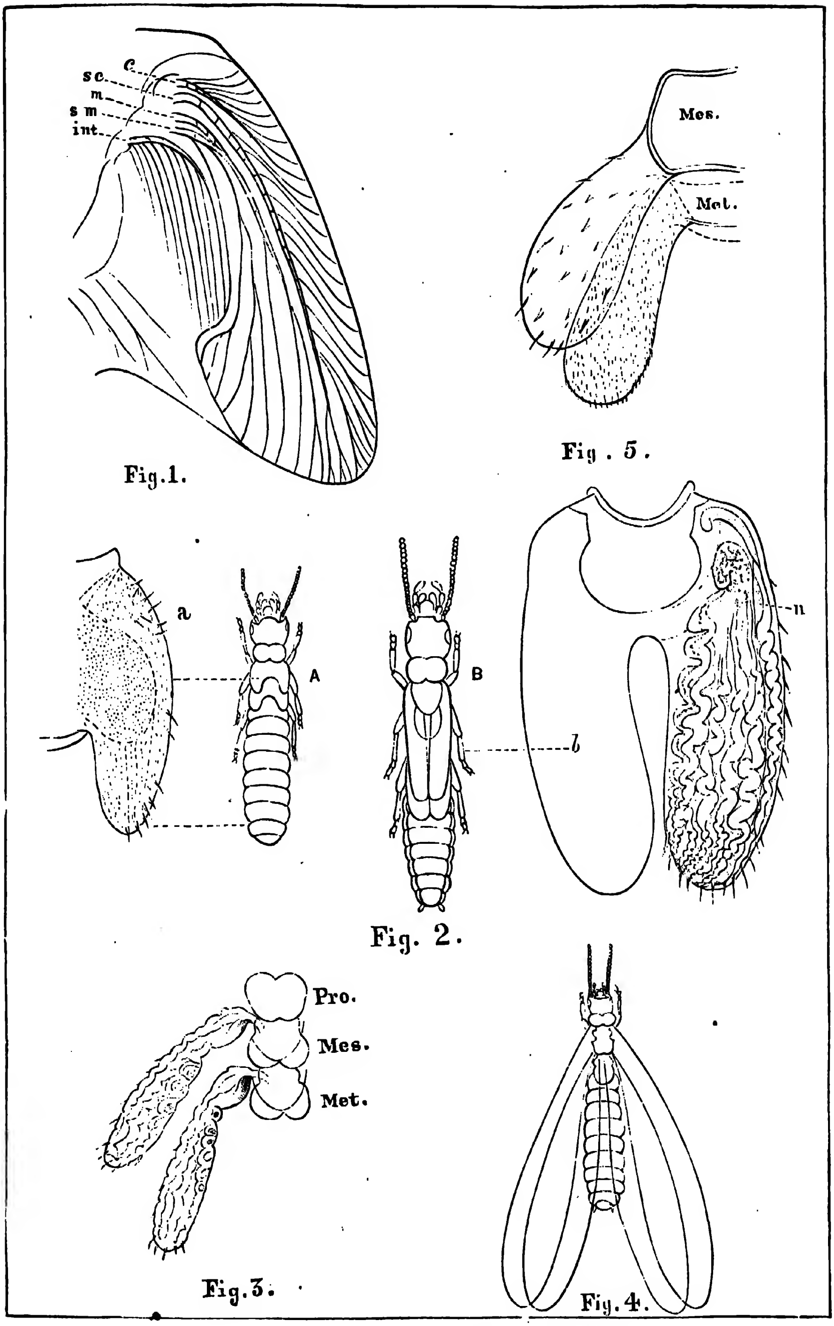
1–5. Limnephilus. 6–10. Panorpa.


1
lbr
3
2
m
sm
gulu
gena
5
4
PRO
sc'
MES
scl'
pscl'
6
sc"
scl"
MET
pscl"
10
11.
7
L
D
9
8
scl"
sc"
scl'
sc'
epis'
MET
cx"
te"
tr"
te'
tr'
c
c

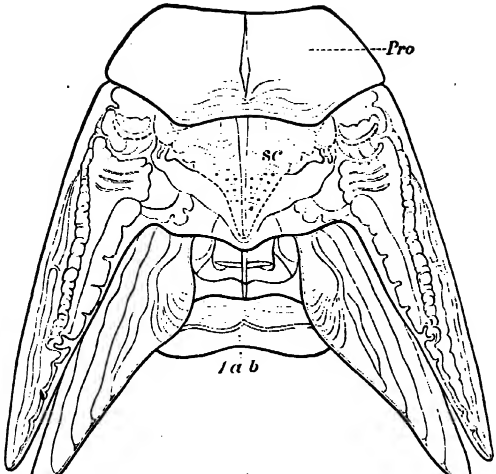
PANORPA.



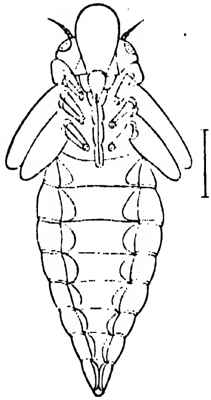
LIMNEPHILUS PUDICUS.



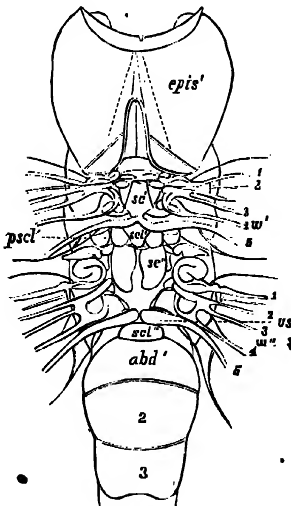
ORIGIN OF THE WINGS IN BLATTA, TERMES, AND PSOCUS.



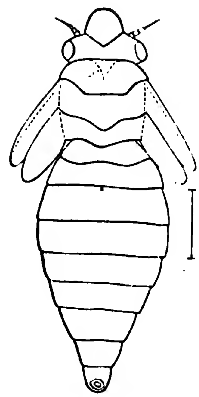
3



1

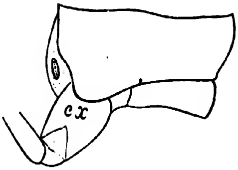


4

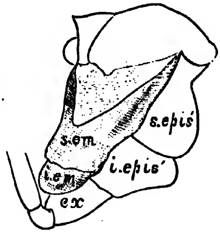


2

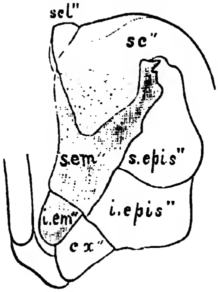
1–3. Aphrophora. 4. Æschna.



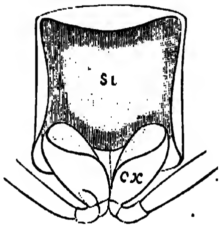
No 1.



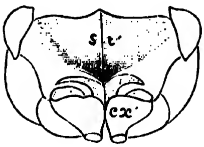
No 2.



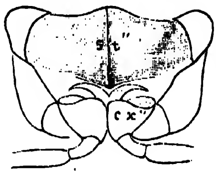
No 3.



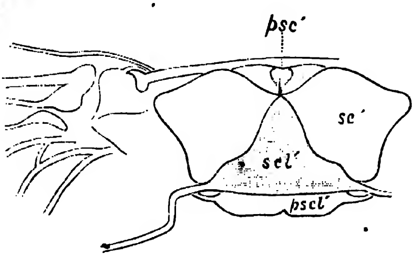
No 4.



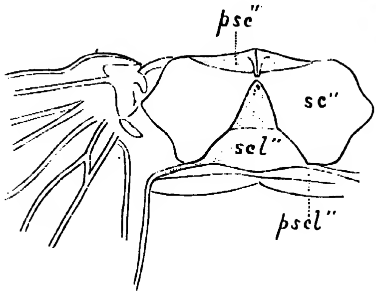
No 5.



No 6.



No 7.



No 8.

Thorax of Corydalus.

APPENDICES.

APPENDICES.

APPENDIX I.

EARLY REFERENCES TO THE OCCURRENCE OF THE HESSIAN FLY IN NORTH AMERICA.

Hoping to find some reference to the occurrence of the Hessian Fly in North America, we looked over the following files of newspapers in the Congressional Library, probably the richest collection of Colonial newspapers in the country. No reference to this insect occurred in the files of the Pennsylvania Mercury, April 7 to December 22, 1775; April 1, 1785, to December 29, 1786; nor in the Philadelphia Packet, October 25, 1773, to January 8, 1776, all that were in the library, the series being quite incomplete. We found the following note in the Pennsylvania Mercury and Universal Advertiser, April 1, 1785, which shows that the ravages of the Hessian Fly on Long Island and in West Chester in 1784 were well known. From the context we have good reason to infer that the insect referred to was *Cecidomyia destructor*.

It is said in the newspapers insects destroyed Lammas wheat last year on Long Island and West Chester, but did not touch the bearded wheat of those places. The farmers, there, imputed the safety of the bearded to its straw being much harder and stronger than the Lammas or plain wheat. They say, too, flour from that bearded wheat is equal to any other among them. A farmer of Maryland asks the aid of the lovers of agriculture for his obtaining a handful of it; to be committed to the charge of Mr. George Mifflin, in Front street, near the coffee-house, Philadelphia; and will be glad to gratify them in return. (Signed, X.)

We also append two articles from the Pennsylvania Packet, written in 1788:

[EXTRACT OF A LETTER FROM FALLS TOWNSHIP, BUCKS COUNTY, MAY 20, PUBLISHED IN THE PENNSYLVANIA PACKET AND DAILY ADVERTISER, MAY 29, 1788.]

The little thing called the Hessian Fly, or insect, I have heard first began to make its appearance on Long Island, and cut off most of the wheat there for several years past, and last season did considerable damage to the wheat in many parts of East Jersey, and near Cresswicks cut off many fields, and even appeared on the banks of Delaware River. Near seed time last year, many persons on the Pennsylvania shore saw the same insect so thick in the air, that they appeared like a cloud coming over Delaware River; and on examining some of the largest flies they had many of their young brood clinging to them, some of which could fly, others not. They have so infested the wheat fields from the Falls Township to Wakefield, and many are of opinion much further, that some persons discovering their numbers have pastured their green wheat, ploughed and planted their fields with spring produce, and more are following their example.

The 17th inst. I went into a wheat field to examine for the insect; some other persons came on the like occasion, and on drawing up either green, dry, or dead spires of wheat, we saw them plenty in each in a white coloured nit, seed, or worm, and where rye grew amongst the wheat it was also full of the insect; and since that time the owner of the wheat field has turned in his horses to pasture, and intends to plant it with corn shortly. I am credibly informed, that it is the opinion of many in Amwell and Hopewell, New Jersey, that they do not expect to save so much as their seed; many of them have ploughed all up and planted with corn. It would be well for all con-

cerned to examine their wheat fields in time, as delays may prove dangerous; and if they discover their fields infested with the insect, it may not be too late to follow the above example.

The insect in the spring resembles a small flaxseed, rather of a rounder shape, but now mostly appears of a white colour, and rather longer than when in their brown colour. They lay mostly and may be found between the first, second and third blades near the root, above the ground, sometimes in the middle of the spire near the root.

TO THE PRINTERS OF THE PENNSYLVANIA PACKET.

As the destruction of the wheat by the Hessian Fly, as it is called, in some of the neighbouring governments for some years past and their penetrating so far into this State, previous to the last harvest, are alarming circumstances, and especially to the farmers, your publishing the following remarks on that interesting subject, we flatter ourselves, will be agreeable to many of your readers and probably convey some useful information to some of them, which may conduce towards alleviating or lessening so great a calamity; if it should in some measure serve this good purpose, the end we have in view will be answered.

JAMES VAUX.
JOHN JACOB.

PROVIDENCE, MONTGOMERY CO., PA.,
Eighth Mo., 16*th.* 1788.

On the 7th of the present month we left home on a tour to Jersey and Long Island, in New York government, to inquire into the effects of that destructive insect, and what remedy had been found to prevent their baneful consequences in these parts; likewise to make inquiry of some of the most sagacious and intelligent practical farmers, who have declined sowing wheat, what mode of cropping they have adopted in lieu of wheat crops, to make annual returns of cash, and in an especial manner to ascertain the true species of bearded wheat which has been found by experience effectually to withstand the attacks of the fly and to procure samples of the same. The following remarks, in consequence of said inquiry, were noted for our own satisfaction and now offered for general information. We find the fly passes itself between the outer straw or husk and the stalk of the wheat until it reaches near the first or lower joint, and there, somewhat like a caterpillar or a twig, fixes its eggs on the stalk, in number from six to eight to fifty; by the growing of them the stalk becomes so compressed with the adhesion of the cluster and weakened to such a degree, as not to support its own weight, consequently falls to the ground and the crop is irremediably lost.

We must leave to naturalists to develop and describe the history of this insect; but to us it appears unlikely that any means, within the bounds of human wisdom, will be found to destroy it, or to tincture the wheat stalks with any noxious quality sufficient to prevent the fly from preferring the common wheat stalks to deposite their eggs for the continuance of their species. We therefore conclude, from the experience of the most intelligent farmers and millers with whom we conversed, that none but uninformed or obstinate men will attempt sowing the common wheat in the neighborhood of the fly, unless compelled thereto by necessity. But this need not intimidate the farmers in the least from proceeding in a regular course of wheat crops, as the fatherly care of the Supreme Being in the course of His providence even in this instance, when the wisdom of His dependent creatures evidently proves insufficient, has interposed and made provision for man's comfortable subsistence, without obliging him to deviate from his usual practice of tillage or his sustaining much loss or even disappointment, but only requires his timely application of the proffered remedy; which seems to consist of *seed-wheat of a peculiar species* and ought to be procured in due time.

Isaac Underhill of Long Island, State of New York, had his wheat destroyed by the fly, consequently had not any for seed; but being a miller, took some out of his mill, which had been purchased from on board a ship at New York in the year 1780 or 1781; this he sowed and reaped therefrom upwards of 20 bushels per acre, when few, if any of his neighbours, for some miles round had any to reap, it being destroyed by the fly; and he, being an observing man, immediately concluded that this wheat must possess some peculiar quality, therefore caused his whole crop to be thrashed out and disposed of it to his neighbours in small quantities for seed. This wheat they have now sowed for 6 or 7 years past and Isaac has never reaped less than 10 bushels from the acre in the most unfavorable seasons, but generally from 20 to 30 bushels. It is a yellow, plump, full grain, with a white beard and white chaff, weighing from 59 to 63 pounds the bushel.

The millers, Isaac and Andrew Underhill, informed us that it was, in their opinion, equal to the best red wheat; and to us, who observed it with a farmer's eye, it appears a perfect grain, much like the yellow Skippack wheat, so highly esteemed by our

millers. The fly will reside in the fields where this wheat is sown and deposite their eggs in the straw, but hardly ever materially injure the crop. The only instance we heard of was a widow woman procured one single bushel of this yellow bearded wheat and sowed it in the same field with the common sort; it was a very small quantity in proportion to the whole field; when the fly had destroyed the common, they attacked the bearded in very great numbers, the crop was much hurt, yet notwithstanding she reaped 5 or 6 bushels from the 1 bushel sown. A man at some distance from the said widow's sowed a field with the yellow bearded wheat, the fly destroyed all the neighbouring fields of the common sort and seemed to collect in his plentifully; from their appearance he concluded his crop would be destroyed; this man reaped about 20 bushels per acre. We found it to be the general opinion there, that this wheat stands the winter better and escapes the mildews more than the common sort and that it ought not to be sowed earlier than the second, third or fourth weeks in the next month, according to the progress the fly has made in the neighbourhood when it is to be sown; for it has been found, by observation, that the fly deposite their eggs in the fall, if the wheat is suffered to grow into stalks before the cold weather pinches them, as the plant, even of this wheat, is then too tender to resist the spear of the fly, if any has, or bear the compression of the eggs, or that the eggs deposited at that early period are most likely to injure the stalk in the spring, before it has acquired a sufficient degree of firmness. The straw of this wheat appears nearly of the same texture with that of rice and is injured by the fly neither more nor less than it. The fly still abounds on Long Island as rife as ever, yet we do not understand any material injury to be done by them save, to the common wheat.

Isaac Underhill lives near Flushing on Long Island, is a farmer and miller, and a person worthy of having the fullest credit given to his opinion in the present case; he was the first person who discovered the peculiar benefit of sowing this kind of yellow bearded wheat, has taken considerable pains to spread the beneficial effects around him; and at this time his philanthropy induces him to promote the general introduction of this invaluable grain.

Andrew Underhill lives in the city of New York, is estimed a man of veracity, is concerned in several mills, took methods early to introduce the bearded wheat for seed in the neighbourhoods from which his mills had used to be supplied; the consequence has been, he has had a full quantity for his use ever since, and his wish is, that the public generally may be supplied with seed. We had our information from many persons on the spot, especially from the two mentioned and from them we have the promise of sixty bushels of seed for ourselves, the present season and are happy to inform our neighbours, that they have promised to procure what is in their power for any of them, who, from inclination or apparent necessity may be induced to send for it.

We found no instance of any farmer substituting other crops in lieu of wheat and but one, of any having common wheat, so as constantly to withstand the fly. The method he pursued was, to cover it with sea-weed or straw, soon after it came up. It appears in this case, as in all others, that there is no general rule without exception; some injury having been done to the bearded wheat, though so little, as not to have the least weight with a person of reflection; as on the other hand, some spots of the other wheat has been preserved in the neighbourhood of the fly, but this happened so seldom that a prudent man will hardly run the risk, when he may, with great probability and at a small additional expence, propose to himself a crop equal to what kind Providence has been pleased heretofore to bless him with.—[From the Pennsylvania Packet and Daily Advertiser, Thursday, August 21, 1786

APPENDIX II.

A.

DESCRIPTION OF THE RYE GALL-GNAT.

BY DR. HERMANN LOEW.

Extracted from "Die neue Kornmade und die Mittel, welche gegen sie anzuwenden sind." Von Dr. H. Loew.* 1859.

VARIOUS VIEWS AS TO THE ORIGINAL NATIVE COUNTRY OF THE HESSIAN FLY.

The Hessian fly became first known in America, in 1779, by the great devastation done to wheat on Staten Island and the west end of Long Island, and, on account of the yearly increasing rapidity of damage, spreading over large tracts of land, was soon greatly feared, the damage done in some cases being from one-fifth to three-fourths of the entire harvest. The idea that the Hessian fly was introduced with packing-straw by Hessian troops who landed on Long Island in August, 1776, soon became prevalent. Later, doubts arose. Some were disposed to believe that it was an American species, and that its immense multiplication was only a consequence of the rapidly spreading culture of wheat; some were convinced that the fly did not occur at all in Europe. After the latter idea had been generally current for a long series of years, and the same was acknowledged as a fact even by scientific institutes, a *Cecidomyia* was observed by Herrick † on Minorca, by Dana near Toulon and Naples, and by myself on the coast of Asia Minor, which fly attacks the wheat in the same manner as *Cecidomyia destructor* in America, and whose larva likewise transforms into a "pupa obtecta." Upon these facts the idea of the occurrence of the fly in Europe again gained ground, and it seems as if the investigators completed the cycle by definitely regarding it as indigenous to Europe, and declared it, as in the beginning, as only introduced. Fitch in his paper strongly holds to this. He partly relies on the authority of Herrick, who, before he made himself acquainted with the species from southern Europe, observed the genuine *Cecidomyia destructor* in America, and regarded them both as identical. Fitch also partly forms this theory from a glance at some specimens of a European species sent to him by Herrick, but so extremely briefly does he report on this comparison that I cannot consent to the proof of identity of both species. Regarding the question whether the species from southern Europe be identical with our rye gall-gnat, I must desist at present, as I neither possess specimens of the former nor a complete description, and my reminiscences of the larvæ and pupæ observed almost sixteen years ago have by the course of time became rather indistinct.

WHETHER THE RYE AND THE HESSIAN FLY ARE ONE AND THE SAME SPECIES.

Whoever specially studies the natural history of the gall-gnats knows that the closely allied species of this genus in the complete state differ at most only by very delicate characters, easily escaping notice, and that in the earlier stages they agree still more among themselves, so that the effects on the cereal which they infest, and the structure of the

* Translated by Dr. C. F. Gissler.

† This is a mistake. Prof. J. D. Dana found the larvæ and pupæ, and reared the flies from wheat growing on the island of Minorca.—A. S. P.

malformations arising therefrom, can be much easier recognized than those irrelevant characters. Without a very close comparison of the natural specimens of the perfect insect, the identity or the difference of species is often very difficult to prove. And yet this must be accurately shown before it is allowed to declare two species as one and the same. As long as there are only presumptions as to their identity, the throwing together and uniting of them leads to new, increased confusion, while the most accurate distinguishing and the most scrupulous care in separating allied species, and not confusing them as one species, warrants and secures our knowledge.

That the whole life-history of the Hessian fly closely agrees with that of our rye gall-gnat cannot be denied; yet it would be hasty to take this congruity, which in closely allied species cannot at all be expected less, for a proof of the identity of the two species. Moreover we find also some small differences. The *Cecidomyia destructor* almost exclusively attacks wheat only, while our rye gall-gnat has hitherto been found on rye only. The maggots and pupæ of the winter generation of *Cecidomyia destructor* are said to occur always only just above the upper end of the root-stock, and those of the rye gall-gnat are usually found a little higher. These differences are too trifling to disprove the identity of the two species. Rye and wheat are such closely allied plants that a gall-gnat, otherwise a very stubborn animal as regards the selection of a certain plant, would very likely choose, according to the inclination of the circumstances, one or the other of the two kinds of plants. Moreover it is not yet proved whether our rye gall-gnat does not infest wheat also.

I shall now compare the insect in its different stages of development. I could not procure any specimens of the American (Hessian) fly, nor was I able to find any in a zoological or private museum. Therefore I must depend upon Asa Fitch's descriptions and illustrations. I notice a conspicuous difference already in the shape of the brown shell surrounding the pupa proper. This shell is less cylindrical and comparatively broader than in our rye gall-gnat, yet much more pointed at its tapering end, while in our species it is blunt, conical. Fitch counts in the antennæ of the perfect insect 16 joints, while they are 18-jointed in all my specimens. Moreover, according to his description, the different antennal joints are in the female connected by thin pedicels that are one-third of the length of the joints, the last joint being at least one-third longer than the penultimate joint; the intervening pedicels between the joints of the female rye gall-gnat are so short that the joints appear to sit one on top of the other and the last joint is scarcely longer than the preceding. I therefore infer that if our species is the real *Cecidomyia destructor*, the demonstration of the pupa and the female antennæ given by Mr. A. Fitch must be wrong, and that, if he correctly describes it, our rye gall-gnat must be regarded as different from *Cecidomyia destructor*. The question can only properly be answered by a comparison with original American specimens, which I soon expect to receive. Without a verification we cannot suppose any inaccuracy in such a thorough entomologist as A. Fitch. We now have, therefore, to regard our rye fly as different from *Cecidomyia destructor* and to call it *Cecidomyia secalina*.

DESCRIPTION OF THE RYE GALL-GNAT.

Female rye gall-gnat (*Cecidomyia secalina*).—The length from the front to the extensile ovipositor is about 1½ lines. Body-color black; humerus, region under the alar radicle, nearly the whole abdomen and the connecting membranes of the abdominal segments blood-red; the ovipositor, consisting of two parts, is more of the color of vermilion, furnished at its end with two very minute, almost round, lamellulæ. The

short and little noticed pilosities on vertex, back of thorax and abdomen black. Antennæ about one-half line long, black; they consist, beside their two basal joints, also of 16 oviform flagellar joints, apparently placed close together, beset with short black hairs. The palpi are blackish-brown, comparatively long, each successive joint becoming considerably longer than the one just preceding. Legs and halteres brown-black; wings grayish-turbid, with short hairs on their surface and with long, black, easily-rubbed hairs along their margins; they only have three longitudinal veins and no transverse vein; the first longitudinal vein is very close to the anterior margin, running just to its middle; the second longitudinal vein is considerably far from the anterior margin and runs from the wing-root straight to the end of the wing, reaching the same shortly before its extreme terminus; the third longitudinal vein is directed diagonally toward the posterior margin, suddenly bending toward the latter with its rather indistinct end, so that it reaches the posterior margin just opposite the mouth of the first longitudinal vein; we also observe that this third longitudinal vein has also a straighter but inconspicuous anterior branch, arising from that spot where it begins to bend toward the posterior margin, and which branch reaches the wing margin just in the middle between the mouth of the second and third longitudinal veins.

B.

OBSERVATIONS ON THE NEW CROP GALL-GNAT, BY DR. BALTHASAR WAGNER. FULDA, 1861; WITH PLATE, 4°, PP. 41.*

Literature.

ASA FITCH. The Hessian Fly. Albany, 1846.
H. LOEW. Die Gallmücken. Program of the Gymnasium at Posen. 1850.
H. LOEW. Die neue Kornmade. Züllichau, 1859.
J. WINNERTZ. Beitraege zu einer Monographie der Gallmücken. Linnæa entomologica. Vol. viii. Berlin, 1853.
VON HOHENHAUSEN. Biographie des Generals von Ochs. Cassell, 1827.
F. PFISTER. Die Fahrt der hessischen Heeresabtheilung von Portsmouth nach N. York. Zeitschrift des Vereins für hessische Geschichte und Landeskunde. Vol. ii. Cassell, 1840.

§ 1. PRELIMINARY CONSIDERATIONS ON THE "SCHEINPUPPE" (SUB-IMAGO STAGE) AND THE IMAGO.

I first observed the maggot of the new gall-gnat in the neighborhood of my dwelling in the spring of 1860. Not until I perused, in July, Dr. H. Loew's paper (1859) did my interest become more excited in the matter. I endeavored to secure specimens of the sub-imago stage. First noticed on wheat only, I soon found that they also occurred on barley and rye. The insect occurred quite rarely on the latter; but on the occasion of an excursion to the Rhön districts I found them as often on rye as on wheat. Both summer rye and summer wheat were attacked. A close examination of the pupæ, as well as a comparison amongst themselves, showed no specific difference. They occurred, as is now generally known, most frequently just above the two lowest stalk-knots, immediately below the ruptured spot, and here mostly on the outer side; less so on the upper part of the knot itself. The number of pupæ occurring on a stalk varied much; sometimes I found but one, at other times seven to nine specimens.

The preserving of the pupæ took place in the open air beneath covers

---

* Translated by Dr. C. F. Gissler.

of mosquito netting on garden-soil mixed with much sand, which was kept moist from below. These net-cages were exposed to every change of the weather, thus imitating the conditions of those not in captivity. During the whole time of observation my attention was also drawn to the metamorphoses going on in the insect in a state of nature. By comparing the latter with those in formation in the nets I believed that the observations were without those mistakes which even the best constructed, but sometimes partially manipulated, net-cages can never fully escape. However much certain objections may be made to raising them in captivity, yet, properly conducted, especially when kept under continued control with the metamorphoses going on outside, its importance is not to be contested; this medium for the determination of the swarming time could not have been omitted in the present case. From the compilation of the collected notes on the hatched flies has resulted the following table. I have to add the remark that the number of flies obtained from the various kinds of crops does not in the least represent a measure of the more or less frequency of the insect in the respective graminaceous genera. For the least would such an inference be made regarding barley. That I obtained comparatively many flies from it is to be explained by the fact that the collection of pupæ was locally more convenient for me. Winter rye yielded few flies, on account of the greater distance of the localities where pupæ would have occurred in quantities.

Kind of crop.	Day of hatching.	Sex.		Number of antennal joints.				Proportions for both sexes.	Sum of individuals.
Winter wheat	Aug. 27		♀		15				
	27		♀		15				
	28		♀	14					
	29	♂				16			
	30		♀		15				
	Sept. 1		♀		15				
	1		♀		15				
	2		♀	14					
	4	♂				16		1:2	18
	7		♀			16			
	13	♂				16			
	18		♀		15				
	21		♀			16			
	24	♂					17		
	29		♀		15				
	30	♂			15				
	Oct. 2	♂				16			
	5		♀		15				
Winter rye	Sept. 7		♀		15				
	9	♂				16			
	26		♀		15			1:3	4
	27		♀		15				
Summer rye	Sept. 8		♀		15				
	15	♂				16		1:1	2
Summer barley	Aug. 31		♀		15				
	Sept. 3	♂				16			
	4		♀	14					
	6		♀	14	15				
	15	♂			15			4:5	9
	26	♂				16			
	28		♀		15				
	28		♀		15				
	Oct. 4	♂				16			
Altogether		12	21	3	18	11	1	4:7	33

Although this table comprises but a small number of individuals, it nevertheless elucidates several important points, as it just answers some questions which are of importance in the characterization of the imago. Of the twelve males hatched, nine specimens have antennæ with 16 joints, in two of them the number of joints is 15 and only in one 17. Most females have 15, three have 14, and two have 16 joints. Hence the normal number of joints for both sexes is not alike, but 16 for the male and 15 for the female.

The determination of the numerical proportion of both sexes for the time cannot, however, be an accurate one, since chance plays an important role in the collection of pupæ, and only by a comparison of *several* generations will a result approximating reality be obtained. However, this proportion probably scarcely remains unchanged in the different seasons of the year, as very likely various circumstances, such as unequal duration of some developmental periods, extraordinary temperature, &c., influence the sexual development. According to the table given that proportion is 12 : 21 or 4 : 7. Hence a prevalence of females over males may be accepted. Also in catching the adults in the field, I captured a larger number of females.

Those 33 developed flies distributed themselves in the various months as follows: August 6, September 24, October 3. The swarming time begins toward the end of August, ending in the beginning of October. The points of time of the beginning and ceasing of swarming essentially depend upon the climate of the location and the meteorological conditions of the year. The climate of Fulda is under the predominating influence of two neighboring mountains—the *Rhön* and the *Vogel*, whose foot-hills approach the city, forming a climatologically important belt toward the south. Our district rises from the surface of the Fulda River, 790 feet up to 1,300 feet above sea-level. By all this a considerable deviation of the physical from the mathematical climate is produced, which must influence the times of appearance of our insect, so that they probably also correspond to the more northern districts. That unfavorable weather produces a remarkable retardation in the development of insects is an empirically known fact, which nowadays entomologists cannot deny. Last year's rainy August is still fresh in the memory of our farmers, no day having passed up to the 26th without at least a few hours of rain, sometimes even lasting uninterruptedly for several consecutive days. We may therefore assume, with some certainty, that owing to the depression in temperature the development of the insect was retarded, the swarming time, therefore, appearing in other years earlier.

The life of the imago is of short duration. I could not keep the flies alive longer than six days, most having died already on the fourth or fifth day.

The hatching gall-gnats were usually not caught before the day following hatching, and were stupefied in ether vapors and then microscopically examined.

§ 2.—Description of the adult insect (imago).

In explanation, I premise the following remarks:

As to the number of segments constituting the abdomen of the gall-gnats the views of authors are at present still divided, since a certain organ at the end of the abdomen receives various meanings. Especially in this respect do the views of those two German dipterologists disagree, to whom the undeniable credit belongs, by their successive as

well as diligent investigations of the hitherto so much neglected natural history of the gall-gnats, of having built a solid foundation and having produced rich material for the preparation of an extensive monograph of this rather difficult branch of entomology. Dr. Loew, in his monograph of the gall-gnats, accepts nine abdominal segments, but does not state their number in his later description of the rye gall-gnat (*Cecidomyia secalina*). J. Winnertz, on the other hand, in his paper, which closely supplements and follows the one just mentioned, includes in the genitals the organ seen by Loew as the ninth abdominal segment, deciding accordingly, as previously done by Meigen, for the acceptance of but eight abdominal segments. I consider Loew's as the correct view. For the sake of brevity I confine myself to our gall-gnat only. Concerning the male (Fig. 17), the genital orifice lies underneath the papillæ subsequently to be described, at the end of a thin, retractile cone, which should be taken for the cirrus. This unpaired organ is by no means on the clasper, but, as in all gall-gnats examined by me, at the base of the clasper itself, from which it follows that the clasper is no appendage, and must be taken, regardless of its small size, as an independent segment. On the abdomen of a female gall-gnat we can in all cases readily distinguish seven abdominal segments. The part following the pygidium is, in the different species, in shape and consistence of various formation, with peculiar pilosity; but this pygidium allows us in all cases to distinguish two segments separated by a transverse fold. In the female of our gall-gnat (Figs. 20, 21, 22) the foremost of these segments is more chitinized; the posterior, yellow segment, placed somewhat transversely toward the preceding, is membranous, elastic, and thereby capable of assuming various forms. According as the ovipositor is more or less protruded the membranous organ expands longitudinally or it contracts, but it is never actually withdrawn as in the ovipositor. It therefore cannot be regarded as a genital organ. Its analogy with the last abdominal segments of many other insects, the pygidium especially is seen in that it likewise serves for the reception of the ovipositor. If we nevertheless reckon it with the genitals we should have to accept in the species with a very tapering, cylindrical, and throughout membranous pygidium not eight but only seven abdominal rings. In a female which, in expiring under the microscope, evacuated a white fluid, I believe I have convinced myself that the location of the anal orifice is really below the posterior end of said organ. Should others make the same observation, the term pygidium would not only agree, but the acceptation of nine abdominal segments for the female gall-gnat would altogether irrefutably receive its justification.

In determining the color of the various body-parts I was led by the following thought. The smallness of the object is to the naked eye very often a hindrance in exactly determining the true color, especially when this is not a vivid one. This case appears when we are prevented by the deviating color of the pilosity from properly distinguishing the parts underneath. Only with the microscope can we get over this difficulty. Under it the hair-covering, previously appearing uniform, dissolves into single hairs, whose color we can easily distinguish from that of the body. Our judgment as to the color of a small, pilose part of an insect, therefore, will turn out variously, according to whether we separate the color of the hair from that of the part itself, or whether we consider the former together with the latter. This is often very important in microscopical observations, and must especially in the present case be contemplated. The legs of our female gall-gnat, for instance, appear to the naked eye as blackish, or black, on account of the pilosity, while

in reality their color is a dirty light-brown. The black-brown color of the male abdomen is intermingled with the light pilosity in a peculiar manner, so that the abdomen has already been called "yellowish-gray."

Another remark has reference to the instability of the color in the imago. The latter manifests in this relation a true Proteus-nature during the first few hours after hatching. The abdomen of the just-hatched male looks dirty—looks dirty light-yellow. Into this yellow soon a hue of red mixes itself, and after an hour the color is already a perfect yellow-red one. Through fire-red it passes into a dirty light-brown, and thence into brown-red. Not before eight or ten hours is the fly completely colored. Not less striking is the change of color of the female, and more so on the ventral side. Already in the opened pupa-shell shortly before hatching it shows a shiny brown-red color, which passes in the just-hatched fly into a vivid crimson, thence going through several hues. The preserved dead female after some time scarcely allows us to distinguish a light hue on the joint-membranes of the abdominal segments. I will, therefore, indicate the color in the description of the imago as it looked to me under the microscope in the *completely-colored, recently-killed* insect.

Male. (Fig. 15.)—Length 3^{mm}. Head and thorax black; abdomen brown-black, lighter at the sides; sutures and median line dorsally usually tawny yellow. Alar radicles and immediate surrounding light brown-red. Apart from the wings the hairiness of all the other body-parts is a *reddish yellow*. Antennæ a little longer than half the body-length, blackish, turned upward, moniliform; hairs verticillately placed, 2+15- to 2+17-jointed, most frequently 2+16-jointed. First basal joint below a little narrowed, second nearly globular, separated from the latter only by a groove; both basal joints sparsely bristled. Knots of the flagellar joints oval, becoming globular toward the tips; style of the flagellar joints only a third thicker but over two-thirds longer than the knots which are scarcely contracted below the middle; last joint sometimes shorter than the penultimate, especially when the number of flagellar joints attains the maximum; the lower verticillar bristles a little longer, the upper just as long as the single joints. Faceted eyes large, lunate, meeting on the front. Ocelli and pigment eyes do not occur. Posterior margin of the head, front, and lower face haired. The light-brown, short-haired palpi consist of four unequally long joints; the basal joint is the shortest; each of the following is longer than its preceding, but also slenderer, the terminal joint as long as the second and third together. They are usually directed downward and curved, so that each of them represents a faint curve with a posteriorly placed concavity. In this position they make themselves conspicuous by active vibration. In dead specimens we find the palpi frequently bent inward or crossing each other. Between the palpi protrudes the yellow proboscis, usually orally retracted towards the mouth; it is blunt, ten-pin-shaped, of about the length and thickness of the second palpal joint. A transverse, in life vibrating, bead above the proboscis I take to be the upper lip. The dorsal part of the thorax (Brustrücken) is strongly arched laterally, beset with long hairs; the whole dorsal surface is divided into three shiny areas by two easily rubbed, longitudinal hair-beads, beginning behind the reddish humeral angle. Scutellum semicircular, brown-black, with its posterior margin sparsely haired. Metathorax naked. Wings without an alula, rounded toward tip, wedge-shaped at base, reaching far beyond the abdomen, gray-turbid; provided with plain, thin hairs directed toward the tip. The anterior margin of the wing is beset with appressed scale-like hairs, the posterior margin with very delicate ciliate

hairs, attaining on the edge of the wing their greatest length, and which, like the hairs of the wing disk, are easily rubbed. Each wing is furnished with three longitudinal veins, the first of which is near the anterior marginal vein, first running parallel with the latter, uniting with it near the middle of the anterior margin. The second longitudinal vein rises straight upward, curves considerably in a posterior direction near its last third, ending yet a little before the tip of the wing. Finally, the third longitudinal vein, which in its lower half is more prominent than the first two, arises from the same root as the second, but strongly diverges from it. Just opposite the end (Mündung) of the first longitudinal vein it divides into two branches, of which one runs in an obtuse angle to the posterior margin, while the other reaches the margin nearly in the middle between the end of the preceding branch and the second longitudinal vein. Both longitudinal veins are connected with each other by a very pale transverse vein, which, directed from the posterior toward the anterior and inner side, meets the first longitudinal vein at half the distance of its end from the roots of the wing. This is the only transverse vein in the wing, and is difficult to see. I succeeded best in finding it by placing the insect on its back, fastening the wing-tips in such a manner that they somewhat rose inwardly. The transverse vein of the wing directed toward the entering light can then be seen by reflected light. A magnifying power of seventy sufficed, while a power of even four hundred did not show it when the wing was kept in a horizontal position. A fold traversing the whole wing immediately before the third longitudinal vein and its anterior corners is very characteristic. The comparatively long *halteres* are light brown. They and the long, slender, more dirty light-brown legs are covered with closely appressed, scale-like hairs, the latter being very regularly parallelly transversely striped. Coxa cylindrical, trochanter (Schenkelring) nearly globular, both of the color of the abdomen. Terminal spurs not present on the tibia. Of the five tarsal joints the first is the shortest; their proportional length is approximately reached by 1 : 12, 5 : 4, 2 : 2, 7 : 1, 3. The terminal joint bears two hair-like, coal-black claws, beneath which is but *one* disk-like, haired cushion. The cylindrical, sparsely haired abdomen consists of nine segments, of which the last, very minute, is of yellow-brown color, posteriorly bearing the dark-red clasper. The eighth segment is smaller than the preceding, equally large segments. Each of the two clasper-halves consists of two joints: the thicker basal joint is not haired on its inner side; on its outer side are three shallow transverse grooves; the longer terminal joint is strongly curved inward. Between the claspers are two pale-brown conical papillæ, densely beset with short hairs, which, as I believe I have observed, act together with the unpaired organ mentioned above as an auxiliary copulatory organ.

Female. (Fig. 18.)—The length from the front to the end of the protruded ovipositor varies between 2.5^{mm} and 3.5^{mm}, and is therefore less constant than in the male. Black is here also the predominating color of the body, being even more intense, shiny velvet-black. Nearly the whole abdomen, the sutures between the abdominal segments, and the median dorsal line of the abdomen are raspberry-red; the base of antennæ and their place of insertion are often blood-red. On the ventral side of each of the six abdominal segments we notice here, better than in the male, a nearly quadrate velvet-black spot, which, however, soon after death loses its distinct margin, the whole ventral then assuming the color of the dorsal side. The pilosity of all body-parts is black; the antennæ are reddish-yellow; the latter are one-third of the body-length;

the number of joints is $2+14$ to $2+16$, usually $2+15$. The female, therefore, has on an average *one* flagellar joint less than the male.*

Of the very short-stemmed, cylindric-oval flagellar joints the lower ones are a little longer than those toward the terminus; the last joint is also regularly longer than the penultimate, sometimes but little, but the plus is often a full one-third of the length. †

Of the verticillate hairs those placed toward the base attain the length of the flagellar knots; the pilosity of the female is altogether much shorter than in the male. The wings reach much less beyond the abdomen than in the male. The abdomen is cylindrical, gradually tapering from the sixth segment. The rose-red-colored ovipositor consists of a cylindrical basal joint and a one-third longer, posteriorly rounded, short-haired terminal joint. The genital orifice is not at the end of the ovipositor, but below at the hind margin of the basal joint. The very convenient position of the terminal joint for the fertilization of eggs while passing out of the parent leads us to suggest the presence in it of a "seminal receptacle." The great flexibility of the last segment allows the female fly to direct the ovipositor downward, which can best be observed in the moment of oviposition. No trace can be found of certain small lamellæ usually occuring in gall-gnats at the abdominal end.

Loew, in his monograph, states as an artificial character of the gall-gnats:

Body long, cylindrical. Legs slender, tibiæ always unarmed, claws weak, only one claw-cushion. Wings large and broad, without appendage, with three to five longitudinal and scarcely one transverse vein, which is placed between the first and second longitudinal veins; wing-margin ciliate, with but seven sections; surface of wing all over with long or shorter intermingled with longer pilosity.

By a glance at the above description the family character will be recognized. Our insect is, therefore, really a gall-gnat. As the first tarsal joint is the shortest and no ocelli occur, the insect belongs to that group of gall-gnats which comprises the two genera *Cecidomyia* Meig. and *Lasioptera* Meig. (excluding the species with non-abbreviated first tarsal joint). Only the first longitudinal vein of the wings approaches more the anterior margin; therefore the insect belongs to the genus *Cecidomyia*. Winnertz subdivides this genus into eight subgenera. The running out of the second longitudinal vein before reaching the end of the wing and the nearly equal number of antennal joints in both sexes allots our insect strictly to the subgenus *Cecidomyia*.

§ 3.—Winter generation.

The period from the egg up to the imago occurs in the life history of this insect twice annually, *i. e.*, the fly appears in two generations every year. That we besides this have to distinguish also another hitherto overlooked case I shall demonstrate at the end of this paragraph. At present we will speak of that generation which is produced by the flies hatching in the fall. We will call it, since it belongs to the cold season, the winter generation.

* An examination of all the raised specimens teaches us that the normal number for the antennal joints (♂ $2+16$, ♀ $2+15$) on the average suffers in seven cases two exceptions, *i. e.*, having one more joint or one less.

† The small stylet connecting both terminal joints we not uncommonly find to be reduced to a minimum, so that it is rather difficult to tell whether there are two or but one joint. To escape any doubt the following remark will be of advantage: Where at least a transverse groove is indicated I decided for *two* joints; where this could not be found I accepted but *one* joint, even if the proportional length perhaps recalled the possibility of two connate joints. It often occurs that some joints may be subdivided by a constriction into two smaller joints. This modification, a consequence of mechanical pressure or of having been dried up after death, will never leave the observer in doubt as to the real number of antennal joints, when he considers their normal proportion of length and the manner in which they are linked together.

1.—*The egg.* (Fig. 1, 2.)

I have observed the act of copulation in our gall-gnat several times. On the 6th of September I brought to a female, hatched early in the morning of the same day, a male. The female sat quietly on the wall of the cage and soon retracted the protruding ovipositor up to near the terminal joint. After the male had flown for a while around the female, he alighted on her, bending his abdomen downwards, embracing the ovipositor with his claspers, thus reaching its orifice from below. Copulation was repeated in short intervals, each lasting from one to two minutes. After this the male was captured and a tender wheat sprout just taken from the soil was placed to the female. After a good half hour the fly ascended on the introduced plant and deposited eggs on the surface of several leaves. With the head directed toward the tip of the leaf, she slowly walked diagonally up, after each short pause depositing two eggs between the intervening spaces of two successive longitudinal leaf-veins, so that, though the eggs were placed in a parallel position, one of them was a little ahead of the other. It could be distinctly observed during the act how the egg each time was expressed by the ovipositor. After removal of the plant a few others were substituted, which were likewise beset with eggs by the insect, wherein, although the process was analogous, a deposition of eggs in pairs did not always occur. In all I counted 83 eggs deposited by the female.

In all cases observed the number of eggs deposited by one female were more than 80 and less than 100. I reached this result either by placing sprouts under the glass globe, as long as any eggs were deposited, or, instead, a whole bunch of sprouts, prepared for it in a flower-pot, was covered with a glass globe and the fertilized female introduced.* After the fly has attended to the care of her offspring, death follows both sexes within a few hours.

The egg has a length of 0.3^{mm} and a diameter of 0.08^{mm}; it is cylindrical, rounded on both ends, smooth, transparent, very faintly light brown or furnished with several red dots, which are often confluent to a single dot, disappearing in a few hours, permanently changing color into brown red.

If we hold the leaves on which our gall-gnat has deposited eggs to the light the latter become conspicuous by a red, silken hue; but if the hatching of the maggots has already taken place, we notice in the small valleys between the longitudinal nerves small excavations; the former position of the ovules and the remaining egg-skins appear as elongate white dots.

Owing to the very minute size of the eggs their gathering in the field is very difficult even to an experienced eye. An examination of the leaves with the magnifying glass requires much patience and endurance. I therefore preferred, with a view of finding eggs, to examine a larger quantity of sprouts of a field, in whose neighborhood the fly formerly occurred in multitudes, and have in this case not only easily found them, but have also found their arrangement to correspond with what has been stated above.

As to the length of time from the deposition of the egg up to the hatching of the maggot I can communicate some observations. Those

---

* Several difficulties occur in the rearing of maggots from eggs, which lie principally partly in the great tenderness, and therefore easy vulnerability of all the parts of our fly, partly also in the less frequent occurrence of the male. Aside from the pilosity, each laceration of the insect foils the experiment to produce copulation. Therefore it requires great care, in capturing especially, since the legs especially thereby receive injury. Furthermore young females obstinately resist all invitations of concupiscent males and the reverse. For the success of the experiment, therefore, *uninjured, fully colored* individuals of both sexes are the essential requirements.

sprouts affected with the eggs of the insect of September 6 soon recovered after replanting them. From 6 a. m. till 9 p. m. the temperature was marked every three hours, and with regard to the then also nightly mild fall weather 1° Réaumur less than the average temperature at 9 p. m. and 6 a. m. was accepted for the omitted nocturnal observations. The hatching of the maggots took place on September 14, eight days after oviposition. From the stated temperatures and the sum of observations (nights taken into account), the average temperature of those eight days was 10.5° Réaumur [55.5 F.]. How much more the development of the maggot from the egg could be accelerated by increased temperature, eggs obtained October 5 yielded a striking verification: the maggot so rapidly developed in a warm room that they left their egg-skins as soon as the third day.

The freshly-hatched maggots very slowly wander downward in the longitudinal valleys between the leaf-nerves. Their motion can only be noticed by looking at them for a long time, especially by means of a magnifying-glass. Several hours pass before the maggot reaches the base of the leaf. After passing the latter the maggot disappears, and, as we find by examining the sprout, continues to wander in the interior down to near the root, to take from this time its permanent seat.

2. *The maggot.* (Fig. 3 to 13.)

The ground color of the larva is white, but when the maggot has just left the egg-skin it shows interiorly a flaky appearance, which in the course of further development forms the so-called adipose body, and which is trajected by a free-moving red liquid, by which the maggot has now a reddish-yellow look. In the movements of the maggot this red liquid accumulates in certain places of the body in lacunes, thereby producing the blood-red spots which appear here and there on the body. The maggot is now elongate-oval, head end pointed, surface bald and finely wrinkled. Its length an hour after hatching is 0.11^{mm}, three times its width, but on the third day already 0.32^{mm}, five and a half times its largest diameter. Of the subsequent developmental phases scarcely anything more is to be said than that the maggot gradually acquires a more elongate form, and that the segmentation of the body becomes more distinct.

The maggot found in the beginning of November, in winter rye, lay head downward, just above the base of the roots.. The maggot had a length of about 3^{mm}. It was white, laterally transparent, the adipose body of a yellowish-white color. Faint lateral emarginations showed fourteen body segments, of which two belong to the head, three to the thorax, and nine to the abdomen. On each side of the fleshy mouth protruded a likewise fleshy sensory point. The extremely small stigmata could be seen on the prothorax and the first eight abdominal segments. The motions of the maggot were so insignificant that they could be revealed only by the aid of a microscope. The retracting of the head was spy-glass-like in two motions. All sprouts on which the maggot was found were either decayed or visibly sick; their yellow-brown color much contrasted with the vivid green of their healthy neighbors.

The sowing of the winter rye begins here and in the immediate neighborhood of my dwelling, especially owing to economical reasons, not before the 20th of September; that of wheat still later. If this sufficiently demonstrates why the gall-gnat used to be found in rye only and not also in wheat, the question, however, was significant: where

do the flies deposit their eggs before the appearance of the winter crop? As I looked for a long time in vain for the maggots of this hard-pressed insect, I was about leaving the greater part of the brood pitilessly to its fate; but I was very soon convinced of my mistake. As is well known, the farmer, to his sorrow, often observes on the barley that, in harvest time, the greater quantity of the straw breaks a little below the ear, which soon disseminates its contents or drops off entirely. If the soil is loose and rich in humus, it will cover itself, especially when favored with some rain, in a short time with young sprouts, often attaining considerable growth in the late fall, and these I, as they appear *after* harvesting, will briefly call "barley aftergrowth." And indeed our flies have chosen this "aftergrowth," being pressed to oviposition, and attacked especially those fields in whose immediate neighborhood the maggots previously appeared in numbers, so that not a *single* stalk remained.*

Owing to this interesting discovery at the end of November I gave up the further examination of the maggots occurring in rye, and followed all the more diligently the development of the easy obtainable material on the so-called aftergrowth. The mild first part of December favored me in finding the maggots. I shall now allude to the developmental stages of the maggots, which however appeared more near each other than after each other.

The maggots discarded their former, more stretched, nearly cylindrical form, the shape now again approaching the originally elongate egg-form of the earliest state. This more robust look was evidently due to the considerable development of the adipose body, which in most of the specimens was distinguishable as a snow-white mass from the remainder of the more transparent body. The segmentation was less distinct than in the formerly examined maggots, as the sides scarcely showed any emarginations. Viewed from above, the head of the maggot seemed to have disappeared, allowing but twelve segments to be counted; on the ventral side of the first thoracic segment the first cephalic ring was represented by a small protuberance, and the posterior segment was sufficiently indicated by a shallow groove, which usually connected with the suture between the first two thoracic rings.

In the least developed maggots the yellowish-white adipose body appeared on both sides in connecting portions, so that transparent portions could be seen only in the vertical line of the longitudinal axis, in which portions the greenish contents of the intestine were visible. Several times in placing such a maggot in a drop of water, tenderly stroking it with a camel's hair pencil, a number of green corpuscles soon swam in the water, evidently issuing from the intestine of the maggot. I take these corpuscles to be chlorophyll granules which the maggot takes in with the cellular juice. Experience that the green intestinal contents of such alcoholic specimens decolorizes strengthens me in this belief. I did not succeed by any means in compelling the maggots referred to to protrude the invaginated head. As the maggot undoubtedly still takes nourishment in this developmental phase, but closely approaches its full growth, it is assumed that the retraction of the head takes place at the moment of separating it from the plant, and that in the extremely slow maggot, when once disturbed in its life-habit, the assumed condition is retained.

A second portion of maggots distinguishes itself by the entire want

* That the aftergrowth has such a great attraction for the flies of neighboring infested fields, a special case taught me: On a field of barley on which I previously could see no trace of the insect the maggots appeared very numerous in the aftergrowth.

of transverse grooves; the body-segments were but partially indicated by slightly bluish transverse lines. The colored liquid concentrated in the dorsal vessel was yellowish-green on account of the underlying intestine. The head was here, as in all forms, retracted. The maggot attains with this stage the maximum of its size, therefore taking no more nourishment. All its motions and bodily modifications henceforth go on within its integument. Therefore an important epoch in the life-history of the maggot is herewith concluded.

To this connective and transitory form belong those maggots which produced by contraction in the direction of the longitudinal axis a partial separation of the external skin, also those which were no more in connection with this skin. The period of pseudo-pupation begins with this moment. The dead external skin, excluded from the life-functions of the organism, becomes now a protecting cover, within which the maggot undergoes the transformation into the real pupa and imago. Through this still white cover we recognize the scarcely changed maggot, and in the latter, especially on removing the external shell, we recognize the reddish-yellow or red dorsal vessel and the snow-white adipose body, which later becomes separated according to the segments into more distinct sections. In consequence of that contraction of the maggot an empty space is produced at both ends of the shell. The shell on some specimens has already assumed a yellow-brown color and denser consistency. The anterior end of the shell plainly exhibits a curvature and a protuberance as a remainder of the retracted mouth, as a sign that the mouth-parts were not excluded in the late change. I owe it to a lucky chance to have had once the opportunity to see through the still slightly colored shell of such a maggot, which pushed the front part of the body back and forth, not only the head with the palpi, but also to observe, how in each forward push the mouth-parts entered behind the mentioned protuberance. The position of the head therefore fully corresponds with that of the protuberance. On the light-brown shell we can better see the punctured transverse lines lining each body-segment than later in the dark-brown pupa.

The rye sprouts infected by our gall-gnat and examined in November and December have taught me that very likely none of those sprouts have sufficient resistance to attain maturity, therefore all succumb to this insect; further on, that, as a rule, the full growth of the maggot coincides with the death of the sprout. The dead sprout for a time serves as a protecting cover, but after its decay the enveloped maggot imbeds itself in the soil. The latter supplies moisture for the preservation of the maggot, to which the parchment like cover moreover yields special protection against the drying-up sun-rays.

The young maggot, as a rule, places itself immediately above the knot from which the sheath of that leaf arises on which the eggs were hatched. On sprouts still wanting an internoded stalk, the leaf-sheaths arise from the root-head, therefore the maggots occur right above there. On the other hand, if the fly finds already a developed sprout, it never deposits the eggs on the lowest leaves, but on blade-bearing ones. Of this I convinced myself on that barley aftergrowth; the maggots were not all the way down, but always in the neighborhood of the two lowest knots, from which it follows that the plants at the time of oviposition of the fly had already developed a stalk. Therefore if the maggots occur on the young winter sprouts near the root, we should nevertheless expect to see a special peculiarity of the winter generation.

3. *The pupa or chrysalis.** (Fig. 14.)

During the winter we perceive no conspicuous changes in the enveloped maggot as taught by an examination after removing the shell. The severe cold has reduced its life-functions to a minimum, recalling its life as an egg, until the vivifying vernal sun penetrates even its coffin-like prison, awakening it from the long apparent death to new activity. The insect at the time is still in its larval state, which, however, it soon discards, entering the pupa state, by which change the larvarium becomes immediately a puparium. The changes which the insect undergoes during pupation advance rapidly and are accompanied by important modifications. The prothoracic stigmata are substituted within a few days by two stigmaphora, and in the antennal region we perceive two bristled organs. Simultaneously the rudiments of the antennæ, wings and legs push forth. The color of the insect in this phase is still a white one, but already, after a few days, the ventral surface assumes a reddish hue, which intensifies with every successive day, gradually advancing toward the dorsal side. The red veins of the future wings are especially conspicuous. All body-parts exhibit, in the course of about a week, a blood-red color. Finally the white pupa-shell is secreted, through which now the more (♀) or less (♂) red body can be traced. The middle of April is the time when pupation begins, but this transition from the larva to the pupa is not the same for all maggots, but comprises a term of several weeks, a fact which should not surprise us if we consider that the time of swarming and consequently also the time of hatching of the young maggots in autumn lasted over a month, and that the maggots occur in the early part of winter simultaneously in various stages of development.

The pupa-shell is the substantially modified former larval skin; we therefore shall recognize in it the form which the maggot possessed; some time after attaining the maximum of growth it separated itself from the inclosing membrane. Its length is sometimes scarcely 3^{mm}, but in most cases from 4^{mm} to 5^{mm}. Its form approaches that of a cylinder with the ventral side more convex, the posterior end blunt, conical, and the rounded anterior end somewhat bent downward. This bending took place simultaneously with the retraction of the head. The upper surface is smooth; very small irregularities, seen under the microscope, obviously originated in consequence of shrinking. The punctured transverse lines limiting each body-segment are, on account of the dark chestnut color, seen under the microscope only. The punctures of the transverse lines produce reflections in white and light brown larval shells after the removal of the worm; the reflections recall the passing of light through very minute orifices; I regard them, therefore, as real pores. The color of the protuberance, being the remainder of the sucking mouth of the free larva, may be brown, yellow, or white. The shell has lost its original membranous structure, becoming so brittle as to break under light pressure.

Now in this shell is the pupa proper, which itself is again enveloped by a white, membranous skin. Its average length is 3^{mm}. As in the Coleoptera and Hymenoptera its antennæ, wings, and legs are also enveloped in separate sheaths, and so ingeniously placed that a glance at such a mummy excites in a mind susceptible to the beautiful not mortal fright, but admiration and pleasure. The wings, folded back-

*This would be the proper place to point out the manner of pupation occuring in diptera in general, and especially in gall-gnats. Loew's paper mentioned above demonstrates this very intelligently; therefore I highly recommend his paper to those finding special interest in the present matter.

ward, resemble coat-tails, and are placed under the distinctly segmented body. The antennal sheaths pass down on the inner margin of the wings, coming from the vertex. Between the antennæ are the parallelly placed, ventrally appressed leg-sheaths, innermost those of the anterior, outermost those of the posterior legs, the tips of which reach about to the sixth abdominal segment. On each side of the thorax protrudes a slightly curved, small horn—the breathing tubes characteristic of the gall-gnats.*

Immediately behind each antenna a short bristle arises from a small, round protuberance. The chitinous structure of the nose-shaped process between the bases of the antennæ seems to be of some service in hatching.

The mode of hatching I never observed in the field, but shall state here my observations made at home. As soon as the pupa has matured it turns around, head downward, and fills out with its abdomen the hitherto empty part of the pupa-case. Thus propped, it raises the outwardly placed dorsal side of the abdomen and cracks the shell; a transverse slit has formed usually through the eighth and ninth segment. The various body-parts are yet so soft and flexible that they can thus be bent. Now, as the insect props the chitinous frontal process against the shell and presses the body toward the formed slit, the latter widens and allows the anterior part of the insect to pass through. After a short recreation from the great work, a few stretchings and jerks suffice to break the thorax of the shell longitudinally. Again comes a short pause: head and thorax become free; whereupon the insect pulls forth the antennæ, wings, and legs out of their sheaths, freeing itself entirely. The young fly now creeps to the light and moves its soft, stick-like looking wings along toward each other with great rapidity until after some five minutes they are fully stretched. After the free access of air has brought its drying and solidifying influence upon the external membranes, the fly finally submits to the bearing capacity of its tender wings.

To remove any objections, as if the narrow space between the stalk and the blade would not allow any motions of the fly, I add that, at the time of hatching, the connection between the lower blades and the stalk is already sufficiently loosened so that there is no want of space for the escape of the fly. In this, perhaps, is the reason why the female supplies the *lower* leaves only with eggs.

The process cannot essentially differ from the above in pupæ lying free on the soil; but as the shell is freely movable, the hatching requires less force by the insect.

4. *The perfect insect.*

From the 17th of December till January 29 the soil was covered with snow; the out-of-door observations, therefore, had to be discontinued for a long time. The subsequent alternation of sunshine and dew (during the day) and frost (at night) proved to be bad for our crops; in some districts over half of the sprouts were killed within a few days. The sprouts infested with larvæ, formerly easily-recognizable (owing to their discolored look), could not be distinguished, after the snow had melted away, from those killed by frost, or if already decayed, no pseudo-chrysalids were found. This was quite inopportune, as I did not collect any maggots in the fore-winter, expecting to obtain in spring ac-

* On the empty pupa shell two long, bristled organs, usually spirally wound above, which appear to connect with the tracheal tubes by a canal, arise out of the thorax-slit, a little before the tracheal tubes. I cannot see for what use they are.

curate results as to the determination of the swarming time. With the consciousness of having previously obtained certainty as to the actual occurrence of the fly on winter rye I became contented to make use of the occurrence on barley aftergrowth. On fields with young clover the straw of this aftergrowth preserved for a rather long period the pseudo-chrysalids I gathered about the middle of March. The result is tabled as below:

Kind of crops.	Day of hatching.	Sex.		Number of antennal joints.				Proportion for both sexes.	Sum of individuals.
After-growth of self-sown summer barley	April 21	♂					17		
	21	♂			15				
	22	♂			15				
	22		♀	14					
	22		♀		15				
	23		♀	14					
	24		♀		15				
	25		♀		15				
	25	♂				16			
	26		♀		15				
	28		♀		15				
	30	♂			15				
	May 2		♀		15				
	5		♀	14					
	5	♂				16			
	5	♂			15				
	7		♀			16			
	9	♂			15				
	10		♀		15				
	10		♀		15				
	10		♀			16			
	10		♀		15				
	10		♀		15				
	12		♀	14					
	14		♀		15				
	18	♂				16			
	18		♀		15				
Altogether		9	18	4	17	5	1	1:2	27

An explanation of the table is scarcely necessary. We again notice a preponderance of females over the males; 12 females have 2+15, four females 2+14, and only two 2+16-jointed antennæ. Of the nine males five specimens have 2+15 joints, only three 2+16, one 2+15-jointed antennæ. In regard to the former table, comprising more individuals, the formula 2+16 must be held as the normal number of the male antennal joints.

Before answering the question as to the duration of the spring swarming time, I draw the attention of the reader to a discovery mentioned at the beginning of this paragraph. I visited on March 23 a field with young clover, which had been sown between winter wheat of last year, of which, therefore, only the stubble was left. On the latter I discovered, with no little surprise, pseudo-pupæ of our insect, which on closer inspection proved to be alive. Investigations during several successive days always only revealed such covered maggots. On April 2 I found also some pupæ proper on the same field; two days afterwards pupæ *only*. That the insects so rapidly transformed into pupæ I principally ascribed to the sudden warm weather. Of the pupæ preserved in the manner previously stated, the first fly hatched on April 13, so that the duration of spring pupation would be twelve to fourteen days. Up to May 12 the pupæ yielded altogether ten flies, *i. e.*, three males and seven females.

Some important inferences can be drawn from these facts. The maggots occurring in the stubble in spring cannot possibly belong to the winter generation, that is, from eggs laid in fall; such an acceptation would not accord with the manner of nourishment of the maggot. We therefore infer that some individuals of the summer generation, perhaps owing to very cold nights which occurred a little after October 1, hibernated and then developed into the imago. The manner of the occurrence of the imago verified this. The scythe was, on account of the clover, kept high, usually cutting off above the dwellings of the maggots, and the upper part of the bent stubble or the blade remaining after the decay of the stubble became a protecting cover for the hibernating insect. Occasionally one or several maggots occurred amongst empty pupa cases, whose former occupants, therefore, had been in sisterly relation to them. These and several other observations remind one so closely of even the most detailed circumstances of the occurrence of the maggots during the previous summer, as not at all to suggest a winter generation.

Since at the time when the disturbing external cause appeared, many of the insects certainly lived not in the larval but in the pupal state, and yet no pupæ were found in March; it follows that *only the maggots hibernated.*

We still lack any special knowledge as to the temperature required for each of the four life-periods when no cessation of development should occur. This temperature is evidently in many cases so unequal that each successive state requires a gradually increased temperature. The looked-for opportunity is seldom offered that a larva in its earlier stages continues to develop at a certain temperature, while another more advanced one is arrested in its growth only to resume growth again at more favorable weather. Of this we have in our fly a conspicuous example. The maggots examined at the end of March from the stubbles allowed us to see nothing from which to infer that they approached the pupa state more than those examined the previous September; the latter, therefore, were already full-grown, having ceased to grow for the length of half a year. Not so the maggots of the winter generation; after they had previously undergone the first phases of their larval state, they developed during the warm days between December 4 and 16 so rapidly that they overtook those on stubble, and then began their hibernation, enduring in it till March. From this it follows that the time of swarming of those hibernating on stubbles for the greater part corresponds with the actual winter generation. But if that extremely favorable December weather had not set in the same could have happened, since, as just demonstrated, the two kinds of maggots do not always conduct themselves alike toward the temperature of the air; the maggots of the winter generation would in this case have made up in spring what the winter made them unable to accomplish before the maggots on the stubble had awakened from their long slumber. As we hold to the present facts, we see in the hibernation on stubble the cause of a partial prolongation of the swarming time, which will certainly be transferred also to the summer generation. Therefore we can, as is assumed, if we adjudge the rye-hibernating insects a somewhat later swarming time, consider the second half of April and the first two-thirds of May as the duration of the spring swarming.

The hibernation of the insect on stubble gives us a key to a judgment of the very probable behavior in variously differing latitudes. Since the theory may be considered valid, that the required time for the development of an insect remains the same only under the same external conditions, but a change of the latter must necessarily be accompanied

either by an accelerating or retarding influence upon the duration of development, our fly will show certain deviations under different latitudes. The following holds for the district of Fulda ($50\frac{1}{2}°$ North Latitude): The eggs out of which the maggots hibernating on stubbles are produced are deposited in May; the perfect insects appear the following year in April and May; the metamorphosis of these flies therefore requires a whole year. On the other hand, the flies issuing just before the beginning of winter undergo two generations in *one* year. So we have a single and a double generation, which will probably also hold for the greater part of northern Germany. Further on toward the north, owing to the earlier appearance of winter, the hibernation of the summer generation becomes more and more frequent; finally, near the polar districts of our cereals, the coming out in fall becomes impossible, so that there will occur but one single generation. On the other hand, in the south there might be observed but one double generation long before reaching the equatorial limits of our cereals.

That the maggots also hibernate on stubble of the other cereals harboring our insect nobody will question. For gathering maggots in spring it is well to choose fields with young clover, because the stubble, under the protection of the wild mustard is then longer preserved; furthermore, as it is well known that wheat straw has more resistance against the weather than the straw of rye, and especially barley, wheat stubbles again deserve attention.

§ 4. SUMMER GENERATION.

The metamorphoses of the summer generation take, favored by the warm season, a rapid course. The flies issuing in April and May find plenty of the food-plants for their offspring. Those of them which passed through the earlier stages on winter cereals oviposit again on the same kind of crop which had already raised a brood; but as the basal leaves begin to decay, the female now chooses stalked ones for her eggs; but those flies which hibernate as maggots on barley aftergrowth or on stubbles are compelled to seek new breeding localities, in which desire they strongly incline to winter wheat. Only when the latter is wanting in the neighborhood do they content themselves with spring cereals, which for the purpose of the fly are sufficiently advanced in May. The hatching young maggots, as in fall, creep to the base of the blade, where they find all the requirements for further development. According to the, at this time, more or less advanced plant, the maggots afterwards occur on the lower stalk nodules, or immediately above the root stock. The spring cereals usually overcome the attacks of the worms by a luxuriant, rapid growth, as they, in spite of the worms, advance on fertile soil. Toward the 20th of June the majority of the maggots are full grown, some of them being then already in the pseudo-pupal state.

As the maggot lives on the juice of the plant, remaining in its first chosen dwelling, this spot becomes so much loosened by extraction of juices that it shrivels, and the stalk, too weak to bear the ear, bends over at the first wind.

It happens, when a strong stalk, that one or several maggots imbed themselves, on account of their sedentary habits, in the soft, yielding substance deeply into the cavity of the stalk; if the spot then heals, *i. e.*, makes it possible by luxuriant growth, that the wound regenerates by new cell-formation, externally all traces of the wound afterwards disappear. Whoever follows this process in nature will not wonder, when he finds the pseudo-pupæ in the interior of the stalk, close to the upper

end of the respective knot. The hatched fly in such a case may be puzzled, when the upper space of the stubble is shut off by the next knot, and no other outlet exists for its escape.

The pupa shells sticking to the stalks usually differ in form and sculpture from those occurring on young sprouts in the neighborhood of the root. Those show a flattening below and above; on the surface occur faint wrinkles and tender longitudinal lines. These and similar deviations from the typical cylinder-form originate by sinking together and drying up of the originally entirely membranous shell.

Peculiar malformations, such as are usually produced by the attacks of gall-gnat maggots on vascular plants, I did not observe, at least on wheat and rye, but on barley aftergrowth the spot where the maggot of our fly rested, occasionally exhibited a knotty swelling.

§ 5. The new cereal gall-gnat as compared with Cecidomyia secalina Loew.

The examinations of our gall-gnat hitherto conducted compel us to a comparison with the rye gall-gnat (*Cecidomyia secalina*) described by Dr. Loew, as for the former we have not yet found a new scientific name. Loew, in the preface of his paper "Die neue Kornmade" [The new Corn-maggot], states it as his principal purpose, to give his observations on the rye gall-gnat such a direction that the hitherto frequent confounding of the maggot with other larvæ shall be avoided, and that, on the other hand, a full knowledge of the developmental history and biology of the insect shall be obtained, as necessary to energetically fight against this enemy of the crops. It is evident that the paper does not pretend to be a complete monograph of the rye gall-gnat. The want of illustrations of his described insect shows this likewise. The few observations known about the fly at the time of writing the paper the author utilized for his description, throughout showing a good authority on gall-gnats.

What Loew states on the biology and the characters of his rye-gnat agrees even in the most minute details with my experiences on the above described gall-gnat, so that it is not necessary for me to give proof of the unity of his with our species. I arrived at a diverse result only in regard to a few rather irrelevant points. Thus, for instance, Loew calls the color whitish in middle of October; at that time I only found the external surface to be so, the inner reddish-yellow. Other differences relate almost exclusively to the coloration of some parts of the body of the female (the male was unknown to Loew). Not too much stress should, I think, be put on those latter differences, as the judgment of color depends nowadays upon subjective conceptions and on diverse causes.

I have yet to add that the pupæ of his *Cecidomyia secalina* sent to me by Loew perfectly agree with those of our gall-gnat, which is again another proof of the identity of his species with ours.

§ 6. Comparison of Cecidomyia secalina Loew with Cecidomyia destructor Say.

In most standard zoological books we find a gall-gnat mentioned, usually under the name of Hessian fly (*Cecidomyia destructor* Say), which for a long time has caused great devastations in wheat in North America. The devastations were in some districts of the United States at times so great that the thought of giving up wheat culture was entertained.*

*As was the case in Ohio, 1857; John Klippart, Jahresbericht über die Verhandlungen der Ackerbaugesellschaften in Ohio, 1858, "Ausland," No. 14, 1860.

Dr. Asa Fitch has thoroughly revised what has been stated on the Hessian fly in various works and journals, has connected the most important facts with personal observations, and has worked up the entire material known about this insect in his paper, "The Hessian fly; its history, character, transformations, and habits," in the American Journal of Agriculture and Science, vols. IV and V, Albany, 1846. After several vain endeavors to obtain this paper, which is rare in Germany, from a bookseller, I finally received it from Dr. Dohrn, in Stettin.

Loew compared his rye gall-gnat with Fitch's Hessian fly, and found differences partly due either to manner of life or to a knowledge of different states of development in both flies, and therefore regarded them as different species. My examinations of our gall-gnat, whose identity with Loew's *C. secalina* I stated in the preceding paragraph, enable me to scrutinize the specific differences of the author of "Die neue Kornmade."

Loew says: "That the whole life-history of the Hessian fly closely agrees with that of our rye gall-gnat is obvious; but it would be hasty to see in this accordance, which in so closely allied species cannot be expected otherwise, a proof of the identity of the two species. Moreover, we find some trifling differences. *Cecidomyia destructor* almost exclusively attacks wheat only; our rye gall-gnat has hitherto been found on rye only."

In § 3, 2, I stated that, according to my observations, the winter generation in our districts, too, besides its occurrence on barley aftergrowth, could be found on rye only. This is explained by the circumstance that, as previously mentioned, the sowing of winter wheat in our districts is done when the swarming time of the insect is almost past. If our farmers gave up the hitherto practised late sowing of winter wheat, the fly without doubt would principally choose wheat for its domicil, such being actually the case in the neighboring districts of the Rhön Mountains, where wheat is only protected against the cold by earlier sowing. In America wheat is attacked by the insect mainly in the fall; by the general practice of early sowing, the attacks of the wheat-midge (*Cecidomyia tritici*, Kirby) are avoided. The fact that the insect infests mainly wheat everywhere under the same conditions, evidently shows a certain fondness of the fly for this cereal, on account of which wheat must be considered as the best adapted food-plant for the maggot. What Loew states regarding the occurrence and life-history of the summer generation, he infers by analogy with the Hessian fly and other gall-gnats known to him, hence it follows that at that time he was not yet acquainted with this second generation. I am therefore inclined to believe that later observations led him to the conviction that the sole occurrence in rye, purely due to external causes, cannot in the least be a characteristic point by which the formation of a new species would be justified.

Further on Loew says: "The maggots and pupæ of the winter generation of *C. destructor* are said to occur always only just above the upper end of the root-stock; those of the rye gall-gnat are usually somewhat higher up."

From what has been said above about the domicil of the maggots and the resting-place of the pupæ in general, this alleged difference loses, as a matter of course, all meaning.

Concerning the imago, Loew says:

Of the American (Hessian) fly, I have not yet seen any specimens; they are wanting in any of our entomological museum collections, nor could I find any in private collections. As to any differences between our rye gall-gnat and the Hessian fly, I must,

therefore, adhere to the illustrations and descriptions given by Asa Fitch. Here I find already a conspicuous difference in the shape of the brown shell surrounding the pupa proper; its case is less cylindrical and comparatively broader than in our rye gall-gnat, also more pointed on the tapering end, while in our species it is blunt, conical.

Special reference was made to the description and illustration of the Hessian fly, and I take the opportunity to tender Dr. Fitch my thanks for his meritorious work. Fitch's paper on the Hessian fly is indisputably a highly important one, being intelligent and attractive, exhibiting great learning and accuracy in this matter. Everybody, in perusing the same, must assent to this judgment regarding the dissertation as a whole. Entering into the details, however, we are not always so fully satisfied. I may instance but one point: In our maggot, as in all gall-gnats, especially in the earlier stages, we can very plainly distinguish 14 body-segments. Whoever follows the development of the maggot pace by pace through all phases will always find 14 segments, and will even see in the pupa shell in the punctured transverse lines the formerly distinctly separated segments. Fitch counts on the maggot before attaining full growth but 12, and in its later stages even only 9 body-segments. I cannot understand how he obtained this result, even if he had but a closely allied form to study. Let us now return to our theme.

Fitch calls the insect in that period during which it is encased (maggot and pupa) shortly "flaxseed." This term should doubtlessly remind us of a similarity with this well-known seed. This results from a citation by Herrick, concluding: "In five or six weeks (varying with the season) the larva begins to turn brown, and soon becomes of a bright chestnut color, bearing some resemblance to a flax seed." In another place the author's own words are: "Though much less flat than a flax seed, its resemblance in color, size, and form, to that familiar object, is so striking as at once to be remarked by every one." To what in the American species does the whole similarity of the pupa case with the flax seed relate? It relates only to color and size, Fitch meaning perhaps only its length; the restriction of the definition "form" by the words "much less flat" perfectly neutralizes and nullifies it. If we now apply the comparison to the shell of our gall-gnat, we must acknowledge that it does not agree either, since the similarity of the shell to a flax seed relates only to color and perhaps also to length. That difference is greater: the shell is scarcely half as broad as a flax seed, never on either side so flattened as that, the pointed posterior end in no case beaked like that end of the flax seed out of which the radicle comes forth in germination. From this we see that the shell of our insect has neither a greater nor a lesser similarity to a flax seed, as attributed to the American species by the above-mentioned two authors.

Fitch, in the beginning of his paper, puts the expression *flax seed* always in inverted commas. Might he not by this have indicated a popular term, which he retained for the sake of easier comprehension, as a concession to his countrymen in his paper? Finally we will also compare the illustrations *o* and *n* given with this description. How little do they agree with it, or even with flax seed! One might think the fruits of *Carex vesicaria* L. were pasted to the wheat stalk.

Dr. Loew says, further on:

In the description of the perfect insect the antennæ are said by Fitch to be sixteen-jointed, while in all my specimens (♀) of the rye gall-gnat they are eighteen-jointed.

The description of the female given by Fitch, says in reference to the antennal joints: "The antennæ (Fig. *e*) are about half as long as the body, and composed of 16 joints, each of a cylindric-oval form." But

soon afterwards it strikes us: "The two basal joints of each antenna are globular." The demonstration in these two points is evidently inaccurate, allowing however scarcely a doubt as to the true meaning of the author. If Fitch, in the first sentence, had included among the 16 joints of cylindric-oval form, the basal joints, he would not have called them globular, else we should substitute an absurdity, which would not be justifiable in the case of so excellent an entomologist. But if we understand by the 16 joints only the flagellar joints, every scruple passes. I must besides recall that the number of flagellar joints in the females varies between 14 or 16; therefore had Fitch really only decided upon 14 flagellar joints, even this could not yet really make a specific difference.

Loew says further on, in relation to differences:

According to his description the joints of the antennæ of the female are connected by thin pedicels, which are one-third of the length of the joints, the last joint being at least one-third longer than the penultimate joint; in the female rye gall-gnat the pedicels connecting the separate antennal joints are so short that the joints appear to sit immediately one upon the other, and the last joint is scarcely longer than the penultimate.

A difference is here maintained due to a mistake in translating. It says in the description (Fitch's): "The joints are separated from each other by very short translucent filaments, having a diameter about a third as great as the joints themselves. The word "diameter" was wrongly translated by Dr. Loew as "length." I found the last in all my examined specimens also longer than the penultimate; but I take Fitch's statement relating to the proportion of length of the last two joints in the given successive meaning as an exaggeration.

I believe now that I have sufficiently demonstrated the untenability of the differences put forth by Loew between his rye gall-gnat and the Hessian fly. That in reality our cereal gall-gnat is identical with the Hessian fly everybody can convince himself who is not afraid to make the study of natural history of the insect for a long time a special matter of inquiry, and who will compare the results obtained by thorough and extensive observations and examinations, which, as I sincerely expect, will deviate only in irrelevant points from those stated in this brief dissertation regarding the manner of life and the characters of the American species in its various stages of growth.

In concluding this paragraph I will not neglect to dwell upon the very closely related question whether the Hessian fly has been already earlier observed in Europe.

Herrick published in Silliman's Journal (vol. XII, p. 154), that Dana, "who, in company with him, made a thorough examination of the peculiarities of the Hessian fly," collected in 1834, in a field of wheat, on the island of Minorca, larvæ and pupæ, from which latter insects issued, which he, assisted by a drawing of the Hessian fly, declared to be *Cecidomyia destructor.* In the same year Dana found the same insect also at Mahon, near Toulon and Naples. Dana forwarded specimens of the imago and pupæ from Mahon to Herrick in America, about which the latter says: "They arrived in safety, and after a careful examination I saw no good reason to doubt the identity of this insect with the Hessian fly." It seems to us that Herrick's (not Fitch's) judgment on the insect received from Europe is not expressed in so "extremely uncertain" a way as Loew thinks. Acquainted with the always inevitable, often indistinguishable modifications of the insect *post mortem*, and the often considerable differences of the pupa-shell of the typical form, a more determined formulation of judgment could scarcely appear admis-

sible; hence this circumspection well authenticates the well-educated thorough entomologist.

The result of the examination conducted through the last two paragraphs is thus realized: our gall-gnat is none other than Loew's rye gall-gnat. This is identical with the Hessian fly, with which the species from southern Europe agrees; *i. e.*, the German, South European, and North American species are all together nothing but *Cecidomyia destructor* Say.

§ 7. IS THE NAME HESSIAN FLY JUSTIFIED BEFORE THE TRIBUNAL OF SCIENCE?

In the various reports on the Hessian fly the year 1778 or 1779 is usually mentioned as the first time the flies began their devastations in eastern North America. As a few divisions of Hessian troops in English service (at the time of the American War of Independence) had arrived during the last few years previous to 1778 on Long Island, the opinion that the new wheat enemy was introduced with packing straw of those troops, was soon circulated, and accordingly the insect was commonly called "Hessian fly." The annually recurring tidings of the more and more widely extending devastations of the Hessian fly, as narrated by Fitch, caused Sir Joseph Banks to make investigations on the insect in Europe, the result of which, as reported by him, was "that no such insect could be found to exist in Germany or any other part of Europe." Upon this the idea that the insect was introduced by Hessian troops was abandoned in America, it being held exclusively to be an American species. But when, in 1834, as mentioned in the preceding paragraph, Dana's discovery of the Hessian fly on the European shore of the Mediterranean, as well as some reports from various parts of Middle Europe, as to similar destructions of wheat in America, were made known, the original idea as to the origin of the Hessian fly started up anew and found especially in Dr. Fitch a very ardent advocate. He especially holds to the assertion of Colonel Morgan, who Sir John Temple assures us subjected the insect to close inspection, and says:

> The Hessian fly was first introduced into America by means of some straw, made use of in package, or otherwise, landed on Long Island, at an early period of the late war; and its first appearance was in the neighborhood of Sir William Howe's debarkation, and at Flatbush.

Fitch adds:

> So many circumstances concur to evince the truth of the account here given by Col. Morgan, to its very letter, that we think no one will hereafter hesitate to give it full evidence [credence].

But continues after this audacious decision:

> We have searched in vain for the date of the embarkation of the Hessian troops, or the number of days occupied by them in crossing the ocean. It is possible they may all have left Europe anterior to the harvest. But in Germany, as in this country, as is shown by M. Köllar's statement, the infested straw becomes broken and tangled and turns yellow, early in June [!]. Had a company of soldiers needed straw for package, no objections would have been made to their going into a field of this kind, and with a scythe, gathering what they required, weeks before the usual time of harvest.

Aside from the very odd perception of Hessian military discipline, it is evident that Dr. Fitch lacked knowledge of just those historical facts which at all events he ought to have utilized as premises of his argument. Let us, therefore, look back into the history of the war of that time for reliable reports on the voyage at sea of the Hessian troops. As the introduction of the insect, according to Fitch, has expressly been brought in relation with that of the Hessian soldiers

who landed on Long Island in August, 1776, we, in the examination, could satisfy ourselves solely as to this transport of troops; however, providing the case, that the introduction of the insect was, perhaps, according to other American authors, in 1777, we will also include the two other transports. The desired explanation as to these transports we find in the "Biographie des Generals von Ochs, herausgegeben von Leopold Freiherrn von Hohenhausen. Cassel, 1827." Major Pfister, in the second volume (page 380) of the "Zeitschrift des hessischen Geschichts-Vereins in 1776. Cassel, 1810," gives a better account of the first transport of troops. We borrow the following from the two sources: The 20,000 mercenary soldiers engaged by the English ministry consisted of Hessians, Hanoverians, Brunswigians, Anspachians, and Waldeckians. The Hessian corps alone amounted to 12,000 men, in two sections. One part of the first Hessian division marched from Cassel, in March, 1776, and was embarked at Ritzebüttel; cast anchor on the 6th of May before Portsmouth; landed on July 7 at Halifax, and at Utrecht, L. I., on August 12, at a time when the English General Howe was restricted to the possession of Staten and Long Islands only. According to an autographical memorandum the other part of this troop-division left Bremen on April 17, arriving on Long Island at the same time with the others. The second Hessian division left Cassel in May, 1776, and landed at La Rochelle October 22. The four Yager battalions sent after were embarked on the Fulda, May 18, 1777; they landed at Sandy Hook September 27. The still later military transports, about one of which Seume, in his biography, has left us a humorous representation, do not concern us in this matter. On the average it took each of the above-mentioned troop-divisions about four months to cross, although the vessels landed nowhere, anchored perhaps for a few days at Portsmouth, the meeting place of the auxiliary troops.

With these facts we will argue the growth of the insect with special reference to its food-plants, to see how Fitch's and his followers' statements agree.

Our wheat here sprouts at about Saint John's day, and a little later we notice a bending of some stalks due to the attacks of the worm, which increases with every successive day. At this time all maggots of our gall-gnat with few exceptions have already entered the pseudo-pupa state; the feeding has just ceased. If we now collect some of the infected straw and preserve it in a proper place, the growth of the maggots goes on in the interior of the shell; but if this gathering happens before the maggots have entered their resting state, *i. e.*, about two weeks previous, when they still feed, they soon die. From this indisputably follows that, if those Hessian troops had really used for packing straw infected with pseudo-pupæ of our insect it could not have been mowed before the end of June. In a dry summer the wheat harvest begins here in the beginning of August; rye usually ripens a week before wheat does. Winter cereals mowed before harvest would, however, require a previous drying to be used for packing. But how, if already in middle of May, not to say March, when both cereals are still in a green grassy condition, could such an occurrence have happened? And where could the pseudo-pupæ have come from, from which the flies issued, which, as alleged, settled them on Long Island?

We see that Fitch has, to support his theory, made assumptions which not only disagree with the developmental history of the insect, but which also appear to one acquainted with the agriculture of our country as ridiculous and absurd. The difference in climate and agriculture between

Hungary (Köllar!) and Kurhessen is far greater than we should expect from the geographical latitude of the two countries. The non-consideration of this very important condition necessarily led the American author to wrong inferences.

We will also briefly speak of the hitherto overlooked occurrence of barley aftergrowth. This aftergrowth sometimes attains, late in fall, such a luxuriant growth and such a rapid development that we could fairly believe the fine, overgrown field of ears would yet mature if the cold were only delayed for a few weeks. The dangerous frost, however, suddenly takes away this hope; a few cold nights, and the lately so vividly greening barley is killed, lying flat on the soil. Under the influence of the spring sun it becomes brittle early in March, so that it, in pulling out, crumbles, and much care is needed to obtain a few entire stalks. It would not have been possible to use this straw for the above purpose.

All reasonable arguments therefore hold that the packing-straw used by the Hessian troops was grown the year previous. Would it be possible that the alleged introduction of the insect was thus effected? We are enabled to answer this question by the experiences obtained as to the metamorphosis of the insect. The swarming time of the summer generation resting above the lowest stalk-knots lasts in Hessen from the end of August* till the beginning of October, therefore not appearing until the wheat harvest is almost over. After cutting, the brood for the greater part remains in the stubbles; the number of pupæ taken along with them is much less. In threshing, usually taking place soon after harvesting, many pupæ may drop off, but certainly as many remain on the straw, a good number of which may develop. We have now to consider the remarkable circumstance of many maggots hibernating in the stubbles. This phenomenon I have demonstrated in sections 3 and 4 by the appearance of frost, since such a low temperature checks the life-power of the maggots, killing that of the pupæ; but that also for those remainiņg on straw, in closed spaces, or at least roofed maggots, a transition to hibernation happens I doubt; the external force would, however, appear for them much later, probably always so late that all favored ones still mature before the appearance of winter. Presuming that some maggots nevertheless hibernate in a barn, and behave during the winter like those on the stubbles, what else could be expected but that the imago would come forth as in those in April or May? Applied to the packing-straw of those Hessian troops, we ought to allow that under the made provisions the military corps which left in March or April could have used such infected straw; but the flies however would have emerged already before the end of the spring swarming time, therefore months before the landing in America, and would have perished, partly on account of their short life, partly on account of the disfavor of their place of birth. I will not tire the reader by still further arguing this matter, else it would necessitate postulations which would, even to Dr. Fitch, appear too venturous. He may have thought that his theory is not applicable to the winter generation, trying it therefore with the summer generation; but it can scarcely be understood how he was led to such an attempt.

I have mentioned in the preceding, through the developmental history of the insect, all given cases which could serve as proper judgment of the view taken by Fitch on the origin of the Hessian fly. His view finds support in none of the mentioned points, being even

*On account of the extremely wet and cool weather for six weeks in July and August last year the swarming time in other years will probably begin a week earlier.

contradictory to them. That every support is now fully removed from his theory of the alleged introduction of the insect by Hessian soldiers is proved by the following circumstance: None of the earlier publications give tidings of the occurrence of the fly in any part of Kurhessen; a devastation of cereals is still less known which could in any way be compared with the late catastrophe. Such devastation ought to have happened occasionally, at least, in some districts during a space of more than eighty years. The appearance of the fly in later years is therefore an entirely new phenomenon.

We have arrived at the following result: The Hessian fly was originally not a Hessian fly, and therefore we must answer the question put on this paragraph, whether the name "Hessian fly" is justified before the tribunal of science, in the *negative*. I now return to our gall-gnat the fully justified original name given to it by the first author, henceforth calling it *wheat-destroyer* (*destructor*).

It would not be without interest, to see from the wording of the statements published in America in the first years of the distribution of *Cecidomyia destructor*, whether the term Hessian fly was in the beginning really used without any secondary signification.

§8.—Attempt at a new theory of the origin of the insect.

Having definitely denied that the wheat-destroyer is indigenous in Kurhessen, I draw the reader's attention to certain facts, which may perhaps throw some light on the origin of the insect. We know the intimate connection of several phytophagous insects with their food-plants. It is certain, for instance, that *Sphinx nerii*, which even in our climate transforms out of doors, was acclimatized in Germany by the introduction of *Nerium splendens* from southern Europe. *Termes flavicollis* Fabricius became distributed over southern Europe and southern France, having been introduced with tropical plants. *Coccus adonidum* and *C. nerii* immigrated in a similar manner into our hot-houses. In plants, which already in prehistoric times took possession of many districts of the earth favorable to them, the connection between gradual distribution of the food-plant and of its harboring insect can either not at all or only indirectly be proved. The difficulty increases when the insect is not restricted to one or several food plants, but, according to climate and season, or in its separate stages of growth, changes with different plants. The wheat worm was hitherto found only on wheat, rye, and barley; its history is inseparable from that of its natural food plants and their original home must *a priori* be also *its* home. Where is the original home of our cereals? Their culture is as old as the history of civilized nations; since all over the area where civilization has taken root the population utilized the cereals. All results obtained by numerous archæological and natural historical inquiries point back in accordance with the Bible and the traditions of ancient peoples to Asia as the cradle of mankind, wherefrom all culture, especially that of the cereals, came forth. There, in the deserts of Persia, on the shores of the Euphrates, &c., is where, according to authentic sources nowadays, wheat and barley still grow under conditions which would not accord with their artificial introduction. In those original localities of our cereals we may also still at the present time be able to find the wheat worm. Loew's own experience, "that a *Cecidomyia* which in its manner of life and metamorphosis cannot be distinguished from *C. destructor* does great injury to the wheat crops on the south shore of Asia Minor"* favors

* Loew, in his Monograph on gall-gnats.

this assumption. The wheat-worm, by the way, offers perhaps the only anomaly among all *Cecidomyidæ* of pupating in the larval envelope.* As we are not aware of any other *Cecidomyia* which destroys cereals in a manner similar to that of the wheat-worm, Loew's reputation not allowing the least doubt as to the correctness of that discovery, the assumption that the Asiatic species is identical with our wheat-worm gains probability.

When Dana discovered the fly† at Mahon the natives said that "the insect had been there from time immemorial, and often did great damage both there and in Spain" [!]. This statement clearly proves that the wheat-worm was distributed from the Orient over southern Europe.

When and from what shore the insect came to America can never be accurately determined. Probably it was introduced several times and at different times. That it happened from the shore of a European state previously possessing colonies in North America must be accepted. It cannot have occurred from England; when Banks reported its non-occurrence in all parts of Europe this may apply to England. Holland and Belgium we may justly omit. On the other hand, not only the long-existing occurrence of the insect in southern France speaks for the introduction from the French coast to the once so extended possessions of the French in North America, but also the comparatively short distance, which facilitated the introduction of infected straw, thus enabling the insect to issue after arriving.

In view of the lively traffic of our continent, existing already centuries before the American War of Independence, with the European colonies on the west, we ought to wonder, indeed, that the insect had been introduced so late. We are *quasi* compelled to assume that the insect existed already some time *before* that war in America, and there, as elsewhere, had only been overlooked. The immensely numerous appearance of the insect in 1779 can only be explained by this. For a proof as to the presence of our insect in America long before the arrival of those Hessian troops we lack, however, all points of consideration. In Fitch we nevertheless meet with a citation which nearly equals the distrust which he himself displays in his preceding demonstration. It oddly sounds thus: The late Judge Hickock, of Lansingburgh, N. Y., in a communication to the Board of Agriculture in the year 1823, and published in the Memoirs (vol. ii, p. 169), says:

> A respectable and observing farmer of this town, Col. James Brookins, has informed me, that on his first hearing of the alarm on Long Island, in the year 1786, (doubtless, 1776 is intended,) and many years before its ravages were complained of in this part of the country, he detected the same insect, upon examining the wheat growing on his farm in this town.

Fitch presumes that the insect found by Colonel Brookins was some other one, and we will not deny the possibility of such an error. But we have to consider that the attacks of the insect upon the crops in summer are not only highly characteristic, but in their consequences so conspicuous that a mistake concerning the insect could happen only in the beginning of its first appearance in a locality. In our country, for instance, after but one year's experience, every farmer knows the pseudo-pupæ of this enemy; he knows exactly how they look, where they occur on the stalk, and so forth. When Colonel Brookins put forth the assertion, scarcely attributable to his patriotism, the evil was already so distributed in America that the "respectable, observing

---

* Winnertz mentions *Cecidomyia graminicola* in his monograph, as likewise issuing from a pupa obtecta.

† Fitch, l. c.

farmer" has certainly not passed the bent wheat stalks without taking a good look at the enemy and comparing it with the one long before observed!

Fitch puts much stress on certain statements of observed devastations of wheat and other cereals made a long time ago in Middle Europe. Scarcely one of these citations has with certainty special reference to the wheat-worm. Baron Meininger's report on destructions by insects occurring in the fields near Weikendorf, in Saxe-Coburg, do not point to the wheat-worm, because the reporter calls the maggot "light-green," which recalls the character of *Chlorops*. All reports from Middle and North Germany published in later years on the wheat-worm agree in this, that the appearance of the insect is an entirely new one. In many districts of North Germany excellent entomologists have not even thus far been able to discover a trace of the insect. A gradual progress of the insect showed itself toward the north within the few later years, sufficiently pointing to their southern origin. Therefore we can infer: the distribution of the wheat-worm can be traced back to the Orient; thence the insect just settled on the islands and along the South European coast, and then was partly introduced to North America, partly and successively progressed in a northward direction.

§ 9.—Parasites.

The wheat-worm harbors a considerable number of hymenopterous parasites, selected by nature to check its extreme multiplication. An accurate knowledge of the natural history of these parasites, belonging to the two groups *Chalcididæ* and *Proctotrupidæ*, is certainly necessary if we wish, in choosing antidotes, to be free of errors.*

Fitch states in his paper, published fifteen years ago, his intention to study "the history of these and other parasites of the *Cecidomyidæ*, and to prepare a special memoir." Whether such a memoir afterwards appeared I do not know. From a sketch copied by him from Herrick's paper there are at least four species of parasites destroying the wheat-worm. One of them, a species of *Platygaster*, pierces the eggs of the fly; of the three other species which presumably pierce the maggot only *Ceraphron destructor* Say is mentioned, and it is asserted that the piercing is done through the leaf-sheath, which I, however, in view of the short ovipositor, doubt. Herrick does not seem to have used special names for the different species; but *Ceraphron destructor* Say became also doubtful, since, as proved by Dr. Foerster in his Hymenopterological Studies (page 98), a great misconception as to the genus *Ceraphron* Jurine was caused by Latreille and later by Nees.

At the time I sent to Dr. Foerster, in Aachen, a sufficient number of the raised parasites, with the request to study them scientifically.

The little that I learned about these parasites I will here communicate. Scarcely a day passed from beginning of August till end of September without receiving some parasites hatched. According to a super-

---

* The law unmistakably applied all through the animal kingdom as to the regulation of the number of obnoxious animals by such as persecute them, and thereby reproduce the eventually disturbed equilibrium, nowhere strikes our admiration more than in insects. There is a considerable number among those which in various ways, by continued practice of their work of destruction, become true benefactors to mankind. But this is not enough. Before in a certain case of devastation the number of parasites gains the upper hand over the devastators, as a rule a number of years pass, often for us accompanied by great losses. Shall we then fold our hands in our laps, surrender the work of destruction solely to our brave friends, carelessly awaiting the catastrophe? Never; this would be wrong and unjustifiable. Man, as the dominator of the earth, was given the faculty of scrutinizing nature and of finding remedies against various hindrances opposed to his endeavors to render the earth inhabitable. The more we progress in the knowledge of insects, the more we study their biology and other peculiarities, the less shall we err in choosing remedies to destroy the enemy.

ficial examination they belong to five species, amongst which are three in which always but *one* insect issues; in the other two species, comprising the smallest species, there are always from three to five specimens in one shell. Those obtained from wheat stubble issued in the time between April 18 and May 30. Two of these are identical with those that had already come forth in autumn. The third species, which I several times found in such immense numbers in April and May on a field of clover with stubble, so that one within a short time could have easily gathered several hundred specimens, is characterized by its deep black color. From these three, too, but *one* specimen comes forth from one *Oecidomyia* maggot. Where those parasites issuing in fall hibernate I could not accurately find out; scarcely in the stubble, because there I never found one of the ichneumons; they may hibernate in the soil. To what the attacks of the parasites are directed, whether on eggs or maggots, or probably on both, requires to be investigated. That at least one or several species pierce the egg is presumed, as I repeatedly found pupæ of the parasites already in the beginning of July in the gall-gnat maggots. Dissections made in the fall on numerous pseudopupæ showed that 60 to 70 per cent. of the insects contained parasites.

Though the great frequency of the parasites on the summer generation was striking, it was not less so that the pupæ gathered from barley aftergrowth yielded not a single parasite; from which I infer an entire exemption of the actual winter generation (not to be mistaken for those hibernating on stubble) from parasites. Fitch received from young infested plants gathered in April only gall-gnats, thus corroborating my idea that the parasites attack only the summer generation.

§10.—Remedies.

The most effective remedy in checking the excessive multiplication of the wheat-worm has been provided by nature herself in the aid received from the parasites just mentioned. To spare them is a very important thing. All considerations and restrictions offered relative to the mode of life of the parasites apply to the choice of the means of destroying the summer generation rather than the winter generation, as the latter does not, as far as is known, harbor any parasites.

Loew, in his memoir, has dwelt at length on the principles regarding the choice of remedies, mentioning first the direct and then the indirect remedies. I will also begin with the *direct* remedies.

1. *Removal of the barley aftergrowth.*

I mentioned in § 3, 2 the aftergrowth produced from self-sown barley, and showed what an important rôle it plays in the natural history of our insect. Unequal maturation of the ears, wind, and pouring rain favor the falling out of the seeds, making its appearance in certain years almost general, while it occurs less frequently in dry, quiet summers; but it will never be missed in any year. On fields with young clover, where the barley-drop is protected from seed-eating (spermophagous) animals (birds, sheep), and soon germinates, on account of the more persistent moisture in the soil, the aftergrowth is most striking. It is this young barley growth which our fly visits for the purpose of ovipositing before the appearance of rye and wheat. The considerable number of maggots, as found by me, is explained by the circumstance that the swarming of the fly occurs at a time when the fields lack any other green crops. We find here the enemy on a soil which

greatly facilitates its attack. This fighting the fly may be done by grazing, pulling out, mowing off, and replowing. The latter may be preferred. To complete the victory our farmers ought not to sow any clover in summer barley or ought to clean such clover fields from barley aftergrowth between October 10 and April 15.

2. *Picking of the sprouts killed by the maggots.*

Dr. Loew expressly recommends this remedy, as he himself witnessed its favorable results upon *Chlorops* attacking winter wheat. I can also add my experience. If we collect in the fore part of the winter the discolored, diseased sprouts, we find on examination that not the gall-gnat maggot alone was the enemy, but often more frequently larvæ of *Chlorops* and other insects. By picking them out of the diseased sprouts we get rid of a good number of other enemies of our crops. Viewed theoretically this remedy certainly promises good results; whether it is practical will have to be considered. To attain our purpose the picking should not be done until when the infected sprouts can be recognized, therefore not before the middle of October; but it should not be done when frost has already set in, as the infected ones cannot then be distinguished from the frozen ones. The work falls into a time which little favors such an out-of-door manipulation on account of the disagreeable weather. The application of this remedy is especially restricted, so that one can hardly proceed on the wet sod or on frozen soil. However, I am convinced that a strict surveillance would pay the expenses incurred.

3. *The grazing of winter crops by sheep.*

To realize the value of this remedy we will first recall the condition of the young cereal sprout, and for this purpose look at a sprout with but two leaves. One of the latter rises vertically; the other, formed earlier, projects off at an acute angle—that is, somewhat rolled up below—showing here the upper part of a third leaf arising from the lip of the previously formed stalk. On the non-bristled end of the cotyledon, which is directed downward, arises the primitive leaf, which is about one-half inch long, as a spatule closing in the base of the two first-named leaves. In unfolding this spatule we recognize usually one or several buds side by side, according to the fertility of the soil. Out of them the secondary stalks develop. The protection of the primitive stalk and the stalk-bud must especially be considered, as their destruction renders the growth of the stalk impossible. As long as the stalk-buds are still covered by the soil frost can do little harm, taking the precaution to previously feed the sheep, and while grazing to continually drive them about.

The flies hibernating as maggots in stubble deposit their eggs, as observed by me, in April and May; also on spring crops when near by. However, such attacked crops should not be grazed, because the sheep would pull out many sprouts.

The value of grazing of winter crops in spring can be demonstrated on a wheat sprout which we may examine in beginning of May. The stalk-buds have in the previous fall pierced the soil, and have formed stalks. In dissecting one we find the inner leaves rolled up, within which is a pale elongate body, the point of the heart. By continual cell formation in the heart the prolongation of the stalk is effected; more and more leaves grow out of this heart, and finally the ear. It is a well-known fact that the growth of the plant is conditioned by the exchange of air through the leaves, and a partial removal of the latter will interfere with

the growth of the plant. To purposely check the growth of the plant may, under certain circumstances, be for the interest of the farmer. If in spring, owing to rich soil and favorable weather, the crops assume an extraordinary growth, possibly causing them to lie down, the evil can be prevented by partial removal of their leaves in order to check the growth of the plants to some degree. If this procedure is followed by favorable weather the plants will soon revive, harvest being then usually fair. But lesion of the heart of the plant is followed by worse consequences; the destruction of that part of the plant so deeply affects the life of the plant that the deformed stalk loses the necessary power to fully develop the ear. We still more approach our purpose if we see to what the sheep which we drive into the winter crops in spring direct their attacks. If we have once witnessed this we have observed that sheep do not content themselves only with the outer leaves of the plants, but that they especially go after the more tender inner leaves. On this account grazing in spring must be injurious the more the crops have advanced. In the present case, meaning to destroy a great enemy, it may be advisable nevertheless in some years to incur this trifling damage to prevent a greater one. Thus we arrived at the following conclusions: Pasturing with sheep is of use at the time of spring swarming, provided the above-mentioned regulations are observed, and only on fertile soil.

4. *Cutting off the tops of the young wheat cropping* (*Cropping*).

This means the clipping off of the upper leaves with the scythe. Care is to be taken not to injure the heart of the plants. This operation is connected with the same conditions as the pasturing. Rich soil is here also required. As the scythe passes over the heart of the plants, but the maggots are in spring near the base of the leaves, cropping will only destroy the eggs. As such it is preferred to grazing, not only on account of its greater success, but also because the operation can be better regulated, not being subject to the choice of the sheep.

5. *Bait.*

As demonstrated, the majority of pupæ remain in the stubble after harvest. It is, therefore, proposed to sow, right after cutting, some furrows with wheat or rye, so that the issuing flies may oviposit on the young sprouts, facilitating afterwards their destruction. There can be no doubt as to the efficiency of such bait. If we, for instance, imagine such bait sown around an infested farm, perhaps also surrounded with woods, the flies issuing during the fall swarming would find bait all around in the stubble; nothing would be more presumable than that in the late fall a number of maggots would occur. Their destruction would be of greater gain for the next harvest, since the non-ichneumonized winter generation would be concerned in their destruction. To bring this into effect in districts with small farms is, however, difficult. To make this remedy very effective it would have to be done in concert by all farmers belonging to the district. Wherever summer barley is raised we shall hardly miss natural baits, and those are, as we know, just that self-sown barley. Whether this is also the case with rye and wheat remains to be established. For various reasons we may adjudge artificial baits to be of secondary importance.

6. *Plowing under, burning, rolling of the stubbles.*

Fitch is very much opposed to these remedies of destruction. Loew partly recommends them. The destruction of the pupæ hidden in stubbles appears to him in years of great frequency of their parasites as a remedy of doubtful value, while he advocates it in years when the latter are less numerous. All reports from America agree in that the fly visits a certain district only for a number of years; then disappears, to reappear after a longer or shorter time. The devastations caused by the insect in its first year of appearance are but little, gradually reaching their point of culmination after three or four year's increase. At the same time the parasites multiply also, not in the same degree, but in a ratio of geometrical progression, so that in the very same year in which the flies are extremely numerous they become overwhelmed by the parasites; hence but few flies appear in the following year. That we in Germany may make the same observations with the fly and its parasites cannot be doubted. Certain practical inferences will be that in a given year we may always know whether to bring the one or the other remedy into application or not. It requires but little consideration to see that already, with 50 per cent. of parasites, the plowing under, burning, or rolling over the stubbles will cause a prolongation of the feeding cycle, therefore doing damage. We can assume with certainty in all cases that but few parasites occur at the beginning of a feeding cycle. The above-mentioned remedies therefore should be applied.

Rolling of the crops has been done successfully in America. That in this way many eggs and maggots are destroyed I doubt, since the eggs in the furrows of the leaves are protected against the pressure of the roller and the maggots are situated very deep in the young sprouts. A good effect could only be obtained by a very heavy roller, and such would also damage the crops.

For the destruction of the spring brood Fitch proposes *mowing* of the wheat, stating an experiment made with wheat two feet high, and wherefrom it resulted that the wheat at this stage can be cut without loss of productiveness. I have had similar experience on rich soil, the rootstock soon producing new stalks not at all diminished in strength. But this occurs exceptionally; the ears never attain the full size, remaining smaller, and in continual drought the experiment is altogether a failure. We therefore consider mowing off too risky for recommendation. Several people have reported that whole "swarms" of our gall-gnat had alighted on cereals for oviposition. Last fall and again this spring I often went on much-infested fields during swarming time at different hours of the day and have gathered flies here as well as on neighboring fields, but never found them gregariously accumulated; on the contrary, they appeared singly. I therefore altogether doubt that it is peculiar to the insect to collect in swarms. Those observations on the gregarious appearances of our fly are either exaggerations or illusions. If our insects had really social habits it would be not out of place to catch them with a net. According to my own observations the catching with a net amounts to nothing at all.

I will now dwell on *indirect* remedies. To those belongs every remedy which gives the plants greater resistance against their attacks, whereby the flies are more or less restricted.

7. *Rich soil.*

The importance of this remedy we have already recognized when speaking of pasturing; it becomes still more evident if we recall the de-

structive effect which the maggot has on the young plant. Each plant that has to nourish one or more maggots above the root-stock, as a rule, perishes. But if on rich soil, the stalk-buds will rapidly sprout stalks, and these will, because swarming has then usually passed, cease to be attacked by the same generation. But on sterile soil, where the root-stocks are lacking buds, cereals will produce no more stalks. All the more so with the summer generation. Plants grown into stout stalks on rich soil render such a considerable resistance against the attacks of the maggots that most of them will mature their ears. The sparsely nourished stalks of a field are easily bent, especially in rain and wind, whereby also the majority of the plants spared in fall submit to the enemy, so that harvesting is very much reduced.

8. *Kinds of wheat yielding a siliceous straw.*

We have cultivated in this district for several years a variety of wheat under the name of "black wheat," which is of robust look, with a somewhat rough stalk. Though it is not spared by the attacks of the wheat-worm, it nevertheless exhibits, as I believe I have observed, more resistance than our other varieties of wheat. The considerable hardness and stability of its straw I ascribe to a greater amount of silicic acid (quartz) in the epidermis. Experiment ought to be made in regard to the power of resistance in various varieties of cultivated wheat.

9. *Late sowing.*

If we compare the circumstance that the swarming of the summer generation ends in the first third of October, with the fact that the maggots occur only on sprouts of *early* sowed fields, we at once infer that we can restrict the attacks of the flies by *late* sowing. We may expect with certainty, if a field is not sowed *before* St. Michael's Day, the sparing by the insect of the crop in fall. How far this practical regulation bears on farming interests the peculiarity of climate and culture of various districts have to decide. Those districts will be less inclined to early sowing where this must be done, because the less deeply rooting sprouts become regularly drawn up by frost, thus perishing by the cold of the winter. The remedy can conveniently be applied to summer barley; at least we can fully protect the common barley (*Hordeum vulgare*) against the attacks of the insect; since its period of growth lasts but nine or ten weeks, the sowing even in the middle of June is still early enough. We will fully reach the purpose in districts threatened by the invasion of the fly, or where the catastrophe has already appeared, if sowing is done within the next three weeks *after* the spring swarming. The first two of the above-mentioned remedies are calculated for the winter, the two subsequent ones for the summer generation. The value of the latter is considerably reduced by the fact that the spring swarming comprises a space of five weeks. So if pasturing or cropping is done in the first week of swarming comparatively few eggs are deposited, but if done later a part of the maggots have already left the egg membranes, placing themselves at the base of the leaf-sheath; the purpose is only partly reached by both remedies. Remedy No. 5 will scarcely ever be introduced, but is recommended to owners of larger farms; little has been decided as to No. 6, still less as to No. 8; Nos. 1, 7, and 9 are regarded as the most recommendable remedies.

APPENDIX III.

THE HESSIAN FLY IN SILESIA IN 1869.

[Extract from Untersuchungen ueber Insectenschaden auf den schlesischen Getreidefeldern im Sommer 1869, von Prof. Dr. Ferd. Cohn.*]

THE HESSIAN FLY.—*Cecidomyia destructor.*

An examination of the diseased stalks fully verified the presumption of Mr. Moritz-Eichhorn that it was not frost but insects that attacked them. All stalks with almost no exceptions were infested with dipterous insects; and though several species were engaged in the work of destruction, yet the Hessian fly devastated the most. Its traces could be seen on numerous dead stalks, which remained span high (12 to 15 centimeters), turned yellow-brown, and dried up. Other stalks developed the two lowest knots, and grew two or three spans high; the upper part of the stalk was withered and shriveled, and surrounded by the likewise dried-up and blackish-yellow leaf-sheaths. Externally on the lower stalk-joints spots could be seen of the shape of a button-hole, 2^{mm} to 3^{mm} broad and 15^{mm} to 20^{mm} long, of straw-color, bounded by a black margin, which latter more or less distributed over the one-half of the stalk-joint, the black coloration sometimes penetrating to the pith; at times two such button-hole-like spots occurred above each other. No trace of an animal could be found on many of the affected stalks; in others the spot was hollowed out, and there were, closely appressed to the stalk, covered by the likewise black leaf-sheath, from one to four smooth, shiny, blackish-brown pupæ, by their flaxseed-like shape easily recognized as those of the Hessian Fly (*Cecidomyia destructor*). Again, in other stalks, the pupæ were higher, at the base of the decayed stalk-point, above the non-attacked, 2 to 3 inches long, lowest stalk-joints, covered by leaf-sheaths. The flies raised by me came out from the middle of June till July 22. It happened that I still found in wheat from Hundsfeld, July 19, besides the brown flaxseed-like pupæ, also white live maggots, together with such just transforming into pseudo-pupæ, the skin having turned yellowish already. The latter, as is known, forms a parchment-like skin within which the maggot becomes a pupa and then a perfect fly, with blackish wings, dark back, and blood-red abdomen; the fly, therefore, leaves the empty brown shell together with the colorless pupa shell, pulled out of the latter. Already, June 15, I observed near Lissa, in company with Mr. Haendler, a field of wheat, a broad streak of which near its boundary, toward winter rye, was similarly attacked as just described at Hundsfeld; here, too, the Hessian fly was the devastator. The same was the case on wheat fields at Rogelwitz, near Mangschütz (district Brieg), where the loss was estimated as five-sixths of the whole amount. From a sketch made by Lieutenant

* Translated by Dr. C. F. Gissler.

Loew, June 15, it showed that a diagonal vein of attacked cereal ran longitudinally through the field.

On July 12 I visited the property of Mr. Josephy, near Striegau, where the English wheat was supposed to have been attacked in this spring by wintering. The wheat, being on very rich soil, though showing a luxuriant growth, was nevertheless recognized as being attacked by frost, since it showed black spots, shriveled stalks which easily broke off from the root-stock, and also a great number of pupæ. The wheat was sowed last fall between October 15 and 20. Director Fellinger, at Schwieben, had also communicated to me the fact that the fly did considerable damage near Tost, but more in rye than in wheat.

APPENDIX IV.

KOEPPEN'S ACCOUNT OF THE HESSIAN FLY.

[Extract from Die schaedlichen Insekten Russlands, von F. T. Köppen. St. Petersburg, 1880.*]

V.—DIPTERA.

a. DIPTERA HAVING A SO-CALLED PUPA OBTECTA.

CECIDOMYIA DESTRUCTOR Say.

Until but lately we had no authentic knowledge as to the presence and injurious habits of the Hessian fly within the limits of Russia, even if several reports have reference to this or allied species. Not until the summer of 1879 were its ravages in the departments of Poltawa and Tola verified by Professor Lindemann in a paper in the Russian language. From this we infer that *Cecidomyia destructor* is distributed over a great part of central and southern Russia.

In certain districts of the department of Poltawa Lindemann found the stalks of the wheat bent and lying down; at the bending occurred, protected by a dried-up leaf, from three to five cocoons of the Hessian fly. The greatest damage was done on summer wheat. Beside wheat Lindemann mentions also rye as its food-plant, but principally mentions wheat. The amount of damage done could not be exactly stated; it was considerable, however. Lindemann himself cultivated an area of 55 dessiatines with winter wheat, examined it, and found that two-thirds of the harvest was destroyed by the Hessian fly. As elsewhere, *Cecidomyia destructor* produces also two generations in one year. The perfect insects appear in the first generation in the beginning of April from hibernated pupæ. The fertilized females, according to Lindemann, deposit up to 200 eggs. This number is certainly too high, and does not agree with reports from elsewhere, according to which the number of eggs deposited is at the most 80. According to Professor Haberlandt† a female deposits only 40 to 50 eggs. The larvæ coming out of the latter live on the lower part of the stalk, covered by the lowest leaf-sheath; they pupate toward the end of May or beginning of June, the imago issuing in the second half of August. The larvæ of the second generation pupate at the end of September and hibernate as such. Lindemann succeeded in obtaining from the pupæ of *Cecidomyia destructor* from the districts of Poltawa and Tola the parasite *Ceraphron destructor*, Say.‡ I leave it to Lindemann as to the correct determination of the name of the parasite. As far as I know *Ceraphron* attacks the larvæ of the Hessian fly, while a *Platygaster* lives in its pupa.

REMARK.—The reports in Russia concerning the gall-gnats allied to *Cecidomyia destructor* are for the greater part so inaccurate that the name of the respective species can be determined only at the outset. How

*Translated by Dr. C. F. Gissler.
†His paper on *Cecidomyia destructor* in Verhandlungen der zool.-bot. Ges. in Wien, 1864, pp. 401–406.
‡Figured in A. S. Packard's Guide to the Study of Insects, p. 375.

far the *Cecidomyia secalina* Löw* differs from the Hessian fly a good deal can be discussed. Nördlinger, Taschenberg, and Kaltenbach follow Wagner,† saying that *Cecidomyia secalina* is identical with *Cecidomyia destructor*. I neither have Löw's nor Wagner's paper, so that I am not in position to verify this view, but should judge from the positive statement of Haberlandt that *Cecidomyia destructor*, at least in Hungary, occurs on wheat only, and that the gall-gnat living on rye must belong to another species. Von Bergenstamm and P. Löw question‡ whether *Cecidomyia funesta*, described by Motschulsky, be not identical with *Cecidomyia secalina* Loew. It is again contradicted by the circumstance that *Cecidomyia funesta* Motsch. occurs on wheat and not on rye. Very likely this species belongs to the subgenus *Diplosis*, for the following reasons: Motschulsky says that his *Cecidomyia funesta* very much resembles *C. verna* Curtis, the latter being a *Diplosis*. This is also verified by the illustration of the gall-gnat given by him, since the second longitudinal vein of the wing terminates *below* its apex (while this in *Cecidomyia* occurs *above* the apex; the difference in the number of antennal joints in both sexes was not questioned, as the single male specimen from which the description was made was without antennæ). The description given by Motschulsky is so insufficient that we accordingly cannot even determine to which subgenus that species belongs. Specimens of the genus *Cecidomyia*, as is well known, soon change after death, losing especially their characteristic colors. Not much meaning, therefore, has the following description by Motschulsky: "Body of blackish-gray color; head and thorax a little darker; legs pale yellowish; wings slightly smoke-colored, turbid, and not transparent, but unicolorous, beset with short hairs at the inner margin. Length, 1 English line; wings spread 2½ English lines." The pupa of reddish-yellow color, 1½ lines long. Motschulsky describes and figures an ichneumonid parasitic on his *C. funesta*. It is the *Platygaster funestus* Motsch. The larvæ of this gall-gnat are reported to attack the wheat in the districts of Saratow and Simbirsk in the same manner as *C. destructor*.

From within the Russian frontiers there are yet several other reports of devastations of cereal gall-gnats. A *Cecidomyia* was observed during several years (*C. secalina* Loew ?) by Zeckert in the district of Mohilef attacking rye. He also observed ichneumonids parasitizing them. According to Czernay, in the fall of 1852 great numbers of maggots came out of *Cecidomyia* eggs deposited on young leaves of winter rye in August in the district of Charkof. The maggots were so destructive that everything green withered. In October they transformed into brown pupæ, five or more specimens of which could be found at the base of the leaf-sheaths. He adds that *Cecidomyia* occurs twice a year—in spring and fall. Professor Czernay gives the following insufficient description: "Body blackish-gray; head and thorax a little darker; wings grayish, brown at the base, beset with short marginal hairs; legs long, blackish, 1 line long. Larva of a reddish color. Pupa brown, elongate, length about 1½ lines. The female deposits some 20 or 30 eggs on the upper side of young rye leaves. The larvæ hatch on the fifteenth day. The pupa hibernates either in the soil or between the leaf-sheaths."

* H. Löw, in the Zeitschrift d. Entom. d. schles. Ver., 1858.
† Untersuchungen ueber d. neue Getreidegallmücke, Fulda, 1861.
‡ "Synopsis Cecidomyidarum" in Verhandl. zool.-bot. Ges. Wien, 1876, p. 73.

APPENDIX V.

THE HESSIAN FLY NOT IMPORTED FROM EUROPE.

By Dr. H. A. Hagen, Cambridge, Mass.*

The official publication of Bulletin 4, "The Hessian Fly," by Dr. A. S. Packard, for the N. A. [U. S.] Entom. Commission, has induced me to study again the question of the importation of this insect by Hessian troops at an early period of the war. The excellent memoir by Dr. A. Fitch was believed to have settled this question in a final manner; therefore his opinion was accepted by all subsequent American writers.

The best German monograph on the Hessian fly was written and published twenty years ago, in Hesse, by Dr. B. Wagner. He acknowledges fully the merits of Dr. A. Fitch's monograph, but he objects to the historical part and the conclusions based upon it. As Dr. Wagner's work seemed to have settled the question so thoroughly that for twenty years no scientist in Europe has believed in the Hessian importation, I was rather astonished to find in the Bulletin a reprint of the old story, without the slightest acknowledgment of their refutation by Dr. Wagner.

I have tried myself to compare as much as possible the different publications quoted by Dr. A. Fitch, and arrived at these conclusions:

1. That it is impossible that the fly could have been imported by the Hessian troops.
2. That it is very probable that the fly was here before the war.
3. That the fly was not known to exist in Germany before 1857.

It has been entirely overlooked that Dr. A. Fitch states himself that he has been unable to fill an important *desideratum*, to make his proofs conclusive ones. He says: "We have searched in vain for the date of the embarkation of the troops or the number of days occupied by them in crossing the sea." There were indeed long before published those data, but in two works which even to-day are not to be found in any library here.† Both these works and the official manuscript report are used by Dr. Wagner. But there exist newer publications, all easily accessible here, but strangely enough, appear never to have been consulted.‡

I.—*It is impossible that the fly could have been imported by the Hessian troops.*

Dr. A. Fitch arrived, after his study of the habits of the fly, to the conclusion "that there is but one mode and but one month in the year in

* Reprinted from the Canadian Entomologist, October, 1880.

† The Biography of the General von Ochs, by L. von Hohenhausen, Cassel, 1827, and F. Pfister die Fahrt der ersten hessischen Heeres abtheilung von Portsmouth nach N. York: Zeitschr. der Vereins fuer hessische geschichte und Landeskunde, Tom. ii., Cassel, 1840.

‡ Max von Eelking: Die deutschen Huelfstruppen im Nordamerikanischen Befreiungskriege, 1776–1783, Hannover, 1863, 2 vol.

By the same author: The biography of General Riedesel, Leipzig, 1856, 3 vol.

Friedrich Kapp: Der Soldatenhandel deutscher Fuersten nach Amerika, Berlin, 1864.

Bancroft's History, vol. viii., ix.

which this insect could probably have been conveyed to this country at that time, to wit, in straw landed upon our coast in August." (p. 29.)

Everybody will agree that Dr. Fitch's reasoning is acute and to the point. As his monograph is known by every student, it is not necessary to repeat in full his conclusions (p. 8–9). But he has forgotten in his calculations that the pupa state of the fly has in the summer only the duration of two months or less, and that every ship for a voyage from Europe required on an average nearly four months; and that straw infested with these pupæ, to be conveyed at this time, must have been taken anterior to the harvest. Dr. Fitch tries to explain this in a queer way: "Had a company of soldiers needed straw for package, no objection would have been made to their going in a field (infested by the fly) and with a scythe gathering what they required weeks before the usual time of the harvest." Dr. Wagner is rather mortified by this funny conception of the military discipline of the Hessian troops. But the supposition is more untenable as the sending of the troops was rather unpopular; their passage was objected to by several parties, and they had to make long and various circuits, and to conduct themselves in a very cautious manner. Further, the minute official reports would have preserved details of such entirely unusual events. The first division of the Hessian troops was ready to depart in the middle of February, 1776. The troops were ordered to march from Cassel through Hanover to Bremen. As the British transport ships had not yet arrived at Bremenhaven, the troops returned to Hesse, and started again February 29. In passing Bremen March 10, every regiment had to be transported on seventy wagons, because the whole country was inundated by the rivers Weser and Wumme. The small number of wagons shows that the baggage could not have been very large. The troops arrived March 21st to 22nd at Bremenhaven, and were embarked from March 23rd to April 15th, as the transport ships arrived only slowly. The fleet started April 17th, arrived in Spithead April 28th, left May 6th, and arrived August 17th at Sandy Hook. Some ships (after Dr. Wagner's statement) seem to have reached Halifax July 7th, and Utrecht, off Long Island, August 12th. Several transport ships left Bremenhaven April 21st, and Portsmouth May 12th, but arrived at the same time with the others at Sandy Hook.

The accommodations for the troops on the ships were all furnished by England. "The bedding," says Bancroft, "was infamous scanty; their pillows 7 by 5 inches, small mattresses and woolen blankets, hardly together weighing seven pounds." Every six men slept together, in a partition 5 feet long and 6 feet broad. When the men were tired lying on one side they had all to turn at the same time to the other side. Now if it had been possible that the bedding contained infested straw, everybody will agree that its use for three months and a half by soldiers placed so uncomfortably is more than the most persistent Hessian fly would be able to stand. The idea that camp straw had been conveyed by the transport ships is of course impossible, when all necessary accommodations had been more than shortened.

The division was ordered, August 19th, from Staten Island to Long Island, and arrived August 22nd at Flatbush. The official records state that only the tents and the baggage were transported on very small and odd looking wagons, each with only two small horses. Here again the supposition that camp straw had been transported is entirely improbable, the more as it is stated that "the troops found Long Island well provided with everything, even to a certain degree of comfort and luxury."

These troops left Hesse in February, and Spithead in May, also long

before straw could have been made, and could not have imported the fly. *These are the very troops Dr. Asa Fitch speaks of with confidence as importers of the Hessian fly.*

The second division of the Hessian troops left Cassel in May, 1776, Bremenhaven June 3rd, arrived at Spithead June 20th, sailed together with the Waldek troops July 20th, and arrived October 21st at New Rochelle, Long Island. The date of their arrival alone proves that the importation of the fly by them was impossible.

All other German troops dispatched in 1776 were landed in Quebec. The Braunschweig troops left February 22nd, arrived at Stade March 5th and at Portsmouth March 20th. The Hanau troops left March 15th, and were embarked March 26th at Nimwegen. Both troops together sailed from Portsmouth April 7th, and arrived June 1st at Quebec. Of course its importation by these troops is out of the question.

During the year 1777 the following German troops were sent to America: From Hessen Cassel, which left March 2nd, were shipped on the Fulda May 18th, embarked May 25th at Bremenhaven, and arrived September 27th at Sandy Hook. From Hessen Hanau, which started March 7th and 31st for Dordrecht; from Braunschweig, which arrived March 12th at Stade; from Anspach Bayreuth, which left February 29th, and were embarked March 30th at Dordrecht. All left Portsmouth together April 7th, and landed June 3rd at Staten Island, and were ordered June 11th to Amboy, N. J. Comparing the dates of their arrival, an importation of the fly by those troops is impossible.

The data for the following years are without importance, as the fly appeared in fall of 1778 in New York. But it may be stated that during 1778 the troops from Hessen and Bayreuth arrived, Sept. 25th, also too late to import the fly.

All troops from 1779 to 1782 landed in Quebec or in Halifax. Only in 1780 troops embarked August 15th arrived October 17th in New York.

I think in comparing all these data, everybody will agree that the fly could not have been imported by those troops. There has doubtless been too much patriotic impulse and indignation prevailing in accepting without any real criticism these old traditions. Patriotic motives are the worst guides in scientific questions.

II. *It is very probable that the fly was here before the war.*

I regret that I am not acquainted with the older American literature, and I have no means to get at it. Therefore I know only one statement, quoted by Dr. A. Fitch, which seems to Dr. Wagner and myself to prove that the Hessian fly had existed here before the arrival of the Hessian troops. The statement (I have seen the original communication) says: "A respectable and observing farmer of this town (Renselaer, N. Y.), Col. James Brookins, has informed me that on his first hearing of the alarm on Long Island in the year 1786 (Fitch says doubtless 1776 is intended), and many years *before* its ravages were complained of in this part of the country, he detected the same insect upon examining the wheat growing in his town. These facts prove pretty satisfactorily that the Hessian fly or wheat insect is indigenous in this country."

Dr. Fitch rejects the testimony with some sarcastic phrases, and adds: "The strong probability is that it was some other insect which was found by Col. Brookins." I don't see how such testimony can be rejected. There is no need to doubt that a respectable and observing farmer would recognize the devastations done by the Hessian fly. Every one, even the most unobserving man, having seen once such a

devastated field, will recognize and remember the fact. Moreover, there has not existed, nor does there exist now in the U. S., according to *Dr. Fitch's own writings*, an insect which produces similar ravages.

Dr. Fitch makes similar objections to the statement of Mr. Mitchell that the fly had appeared on Long Island in 1776, before the arrival of the troops. He says the devastations were conspicuous and liable to attract attention, and leaves us in the dark when Col. Morgan states that in 1778 the fly made its first appearance, and directly after that Mr. Clark states that the fly made its first appearance in 1779, so that at least one of them must have been mistaken.

III. *The fly was not known to exist in Germany before* 1857.

The fly must have existed in Europe and in Germany before it could have been imported with the troops. Dr. Fitch tries to settle this most important question by the following statements:

Mr. Duhamel, in Monceau (I have compared the original), says that "a number of white worms have been found on the wheat near Geneva, in 1755, which after a time turn to a chestnut color; they place themselves betwixt the leaves and *gnaw the stalk;* they are commonly found betwixt the first joint and the root; these animals appeared about the *middle of May*."

It is rather strange that just this passage has been quoted and always reprinted. Mr. Duhamel says plainly, "The larva gnaws the stalk." Now Dr. A. Fitch says (p. 33), "The larva of the Hessian fly lives upon the sap; *it does not gnaw the stalk*." And Dr. Packard says (p. 15), "Their soft and fleshy undeveloped mouth parts *do not enable them to gnaw* the surface of the plant."

The fact that the stalk was gnawed shows evidently that the insect was not the Hessian fly, but a species of *Oscinis;* the larvæ of some species of which would gnaw the stalk—or perhaps *Opomyza florum*. The pupa of those species is also brown and appears above the root between the leaves and the stalk, and the imago appears just as Duhamel states, in *the middle of May*, one month later than the Hessian fly. Prof. J. Kuehne remarks that the effects produced upon the plants by *Opomyza* are similar to those of the Hessian fly.

Therefore the quotation of Duhamel is entirely out of place, and this is, by the way, *the only one* by which the existence of the fly in Europe before the war has been corroborated. I have gone through the literature from 1770 to 1804, without finding any statement of similar devastations of wheat, for Germany, for France, and for Spain. There exist a number of books where such a calamity in France would have been noted if it had existed.

I have not been able to consult the long and detailed report of Sir Joseph Banks to the British Government. An extract given by Kirby and Spence shows that the fly did not exist in England in 1788, and that nowhere on the continent its existence or similar devastations were known.

In 1834, Prof. Kollar, of Vienna, in his treatise on injurious insects, published an account on some devastations done by the Hessian fly—he has first in Europe used this name for a European species—in Altenburg, Hungary, and in Weikendorff, 17 miles from Pressburg, an estate belonging to the Prince of Sachsen-Coburg. Dr. A. Fitch quotes both as "Saxe Altenburg and Saxe Coburg, about a hundred miles distant from Hesse Cassel." "It is a strange geographical mistake," says Dr. Th. W. Harris (Corresp. p. 189), "to transport those localities to Saxe, whereof Altenburg is 400 miles distant, and Weikendorff near the border of Hungary, about 375 miles distant." Nevertheless Dr. Packard

reprints again the strange mistake made by Dr. A. Fitch, as *the only proof for the existence* of the insect in a district not far distant from Cassel.

The careful study of Prof. Kollar's report makes it very doubtful if his insect is the Hessian fly. He describes the larva as pale green with a small black dot above, which does not at all agree with the Hessian fly, but very well with the larva of a *Chlorops*. He states having reared *but one fly*, but he describes *both sexes*. His description is simply a translation of those of Th. Say, and not a correct one, as he translates several times fulvous for golden.

I have never seen the dissertation on the same calamity by Dr. Hammerschmidt, Vienna. It is printed in a small number for private circulation. Prof. J. C. Westwood having received specimens of the pupa in the sraw, doubts if it is the Hessian fly. Perhaps the strictures on his report by Dr. A. Fitch (p. 8) are correct, as they have never been refuted by Prof. Westwood. But it is to be remarked that *C. destructor* is not the only species of the genus having a coarctate pupa. Dr. Fitch (p. 40) has detected one on *Agrostis lateriflora*, and Mr. Winnertz states the same for *C. graminicola* from Europe.

All European works on the Hessian fly published after 1857 agree that it was then an entirely new pest, never seen before and unknown to all prominent dipterologists—Wiedemann, Meigen, Zetterstedt, Loew, Bremi, all monographers of this genus, and Schiner. The species was represented in no collection, and apparently not in the Vienna Museum, as Mr. Schiner, 1864, quotes as localities for Europe only those given by Mr. Dana. Nevertheless I am obliged to state that thirty years later, after Mr. Haberlandt, the Hessian fly, *C. secalina*, has been observed in the same parts of Hungary.

The only sure statement of the existence of the Hessian fly in Europe is its discovery by Mr. J. Dana in 1834, at Mahon, Toulon, and Naples. The identity of this insect with the American species is to be accepted on Th. W. Harris's authority. There was never a better authority, and scarcely one who has better known the insect. He has given his conviction of their identity in the most unequivocal terms. The statement that the insect had been in Minorca from time immemorial, and often done great damage both there and in Spain, is very interesting, but not to be accepted as certain before having been corroborated by reliable reports. I am not able to compare the old Spanish literature, but I think it should be done.

The existence of the fly in Asia Minor, near the shore, is probable from the discovery made by Professor Loew of the larva and pupa on the straw in 1842, and later recognized by him as identical with his *C. secalina*.

Mr. V. von Motschulsky describes in 1852 a fly very obnoxious to the wheat in the governments of Saraton and Simbirek, in Rusland, as *C. funesta*, together with its parasites. I may add that von Motschulsky, after his return from America, and having received typical specimens of the Hessian fly and its parasites from Dr. A. Fitch, has assured me that *C. funesta* and *C. destructor* are the same species. This is also accepted in von Osten-Sacken's catalogue. Mr. Koeppen, in his excellent work just published "On Injurious Insects in Rusland," states that since that time nothing has been known about the fly in those parts of Rusland. "Before 1879," says Koeppen, "we had no reliable report about the existence of the Hessian fly in Rusland, which was discovered in Poltowa and Sula by Mr. Lindemann in the summer of 1879, together with its parasites."

In 1857 and 1858 the rye was extensively damaged in Silesia,

Posen, and Prussia. Prof. Loew, at the time the leading dipterologist studied the insect, and declared it to be very similar to the Hessian fly, but probably a new species named by him *C. secalina.* He had never seen the American species, and had to rely on Dr. A. Fitch's description, which did not fully agree with *C. secalina.* In 1859 the same insect was very obnoxious to the rye in Eastern Prussia, and was studied by myself. In 1860 it had advanced westward to Augusburg, where it was studied by Prof. Rosenhauer, and to Fulda, Hesse. Everywhere it was considered to be an entirely new pest, never seen or observed before. In Hesse the fly was studied by Dr. B. Wagner, and his monograph is perhaps the most satisfactory existing in Germany, though it seems to be entirely unknown here. The fly destroyed in Hesse wheat, rye, and barley. I am not able to say whether the insect did advance farther west. In the following years the calamity subsided, and was soon nearly forgotten. Extensive destructions in Hungary in 1864 are reported by Mr. Haberlandt and Kuenstler, and in 1879 in Rusland. I find no statements of injury done by the fly in Germany after 1860, and the reports for Bohemia for 1872 and 1879 state directly that the fly was not observed. Dr. Schiner, in Vienna, had till 1864 seen no specimen; the best proof that it had not been obnoxious in Austria.

Dr. Wagner was the first to acknowledge the identity of *C. secalina* and the Hessian fly. In observing the manner of life and the time of swarming of the fly in Hesse, and comparing both with the time of the departure and the arrival of the Hessian troops, Dr. Wagner comes to the conclusion that the importation of the fly by those troops is strictly impossible.

If we consider the positive evidence of the existence of the Hessian fly in Europe, we find that between 1830 and 1840 it occurred in four localities on the northern shore of the Mediterranean. It appeared in 1850 more to the north in southern Rusland, and advanced strictly westward through Germany till 1860 as a very obnoxious pest. After all I think it would be hardly more difficult to accept and to prove that the fly was introduced by the energetic trade with the Mediterranean from America, and became obnoxious only after acclimatization, as to accept the introduction into America from Europe. It is difficult to suppose that the fly had been overlooked by such a number of prominent entomologists as those named. Dr. Wagner accepts as a fact that the fly was imported from Asia to Europe and from Europe to America. The same supposition was made long ago by T. W. Harris, because the fly is connected with the cereal grasses, and therefore their original home was presumed to be the same with those plants. Against this conclusion I have to make two objections. First, the fatherland of these plants is unknown. That they live still wild in Persia, as Dr. Wagner supposes, is not proved at all. Buffon also remarks that our cereals are not known to grow wild anywhere, and later statements have always been proved to be unfounded. The fly is not found till now in the Orient. Second, *it is not true* that such an obnoxious insect is strictly limited to some few species of plants. The potato bug has given abundant evidence that an insect not obnoxious before may become so by finding a related plant better suited to its taste. Dr. A. Fitch (Rep. II., p. 297) well says, in speaking of some wheat and barley flies: "As these flies appear to be native species, it is probable that before wheat was cultivated upon this continent they sustained themselves upon some of our wild grasses. Their numbers must therefore have been very limited at that period. But when wheat was introduced and became extensively cultivated, it gave them such an ample supply of most palatable nourishment that they have gradually increased, and are now excessively

numerous, laying every wheat-field under contribution for their support." Is it not obvious that the same course may have happened with the Hessian fly? The more so since just at the time of its appearance in Long Island and the adjoining country the culture of wheat was prominently advanced. Since we know that at the utmost during six weeks in the year only is the importation of the fly possible, such an importation to America before the discovery of steamships is almost inconceivable. Even if purposely undertaken with all care, such an importation would almost surely have been a failure.

Dr. Wagner has felt the strength of those arguments, and supposes that importation had been possible only from the nearest coast of France. He believes that the lesser distance, as well as the frequent trade with France, makes it more probable. But why not accept that the fly was indigenous here as well as in the Old World? There are Diptera identical with European species which nobody would think to have been imported. I may mention the common *Trichocera regelationis*, which belongs to a related group. The species is common here, and was observed by me 13 years ago. But last winter I had specimens sent me from Maine, stating that this insect had never been seen there before, and had been extremely troublesome. I know well that many animals—higher and lower ones—have been imported, because the facts are well recorded; I believe that a number of others have also been imported for which the facts are not recorded. But I see no reason to go farther, and am prepared to accept that the same species in both countries may have been developed under similar conditions. I consider, therefore, the Hessian fly to be an indigenous American insect, and not imported by Hessian troops.

A few words more concerning the periods of unusual abundance of the fly. I was very much interested in the study of the table given by Dr. Packard, but I arrived at the conclusion that the table is not sufficient, and indeed is considered by Dr. Packard himself as very imperfect. Concerning New England Dr. A. Fitch's statement has been overlooked, Regs., viii., p. 203, that the fly was very injurious in Berks Co., Mass., in 1779.

The year 1823 for Maine and 1857 for Ohio, are not marked at all in the table, and both the records state that the farmers had ventilated earnestly the question to give up entirely the cultivation of wheat. The only conclusion to be made by the table would be that with an intermission of thirty to forty years a period of superabundance follows. Perhaps a careful study of the old records from 1748 to 1750 would give some evidence if the fly has ever been obnoxious here before the war. It is a curious fact that such an intermission of the appearance of the Hessian fly has occurred just in that quarter of the century during which the most ardent collector and student of the N. American Diptera—I may say the founder of the American Dipterology—was here. In fact, Baron von Osten Sacken has never met here with this Hessian fly, which is not represented in his collection nor in Prof. Loew's, both now in the Museum in Cambridge.

NOTE.—As the paper was going through the press I received two pairs of *C. destructor* from Prof. J. A. Cook, the first American specimens which have come to my hands. In comparing these with two pairs of *C. secalina* from Prussia and Hesse, I was astonished to find the American insects twice as large as the European ones, and almost entirely black. I think they look so different that the identity is perhaps not sure. But a larger series from both countries and a more detailed knowledge of Diptera than are at my command would be needed to decide the question.

APPENDIX VI.

MR. JOHN MARTEN'S REPORT ON THE ROCKY MOUNTAIN LOCUST IN 1880.

Dr. CYRUS THOMAS,
Of the United States Entomological Commission:

SIR: I have the honor to report that in obedience to your instructions I have visited personally portions of southern Minnesota, central and northern Dakota, and eastern Montana for the purpose of gathering information in reference to the locusts.

My investigations under your letter of instructions were confined to July and August, 1880.

Leaving Carbondale, Ill., July 5, I passed up the Illinois Central Railroad to Chicago, and from there to Saint Paul, Minn., over the Chicago and Northwestern Railway, where I stopped one day. From Saint Paul I went to Willmar, Minn., on the Saint Paul, Minneapolis and Manitoba Railway, where I arrived during the afternoon of the 9th instant.

I could not discover by inquiry that any damage had been done by locusts along the line of the railroad, but I saw a few of them at stations where the train stopped.

At Willmar I learned that in August and September, 1876, swarms of locusts came from the west and northwest and deposited eggs in large quantities, preferably in sunny spots nearly or quite clear of vegetation, though large numbers were placed in the open prairie among the grass. These eggs hatched during the latter part of May and in June, 1877, the young locusts stripping the fields of almost every green thing in some places, causing many farmers to take advantage of the offer of seed made by the Governor of the State. In June and July the locusts departed in swarms, going towards the south and southeast. The crops most damaged by the young locusts were the wheat, oats, and other small grains; gardens were also damaged very extensively.

I could learn of no damage done by locusts in this vicinity during either the past or present years, and many averred that there were none of the pests in the country, though I captured several specimens in fields near the town.

In examining a field of rye, many of the stalks, perhaps one-tenth of those on the side of the field where I was, were perforated by some insect from two to four inches above the second joint from the head. The perforations had much the appearance of those made by the subgenus *Chlorops* of the two-winged flies. Above the perforations the stalks were dry and the heads only chaff.

My next stopping-place was Glyndon, Minn., where I remained only long enough to take the first train westward. Along the railroad from Willmar I captured several specimens of *C. spretus*, but could not learn of any ravages committed by them at any time during the past year.

From Glyndon I went to Jamestown, Dak., arriving there Saturday, July 10, having learned nothing along the route of damages committed during the two years just past.

For information and assistance while in Jamestown I am indebted principally to Mr. A. W. Kelley, the postmaster.

Locusts first visited this section, to his knowledge, in 1869, at Fort Totten, some eighty miles north of Jamestown, he having previously, in 1864, seen them at the old Yellow Medicine Agency. During every year from 1869 to 1876, inclusive, locusts occurred in greater or less numbers, and eggs were deposited at various places along the valley of the James River. The locusts in depositing their eggs generally selected a sandy, rather compact soil, choosing the low ground next the river rather than the more elevated prairie, even where the higher ground was but a short distance from the river.

Of the swarms stopping here the greater number came from the north, some coming from the northwest. They departed towards the south, southeast, and the southwest, though in 1876 and once previously they were noticed flying toward the northwest.

In July, 1879, they were flying over Jamestown toward the southeast. Among the things attacked by them were wheat and all other grains, onions, cabbage, potatoes, &c. Tomatoes were among the last things eaten, while pease escaped almost entirely. In 1879, June, just across the river from Jamestown, about one acre of beans were destroyed by young locusts that had hatched in that place. This is the only instance of note in which the young locusts have appeared in any considerable numbers and have done damage during the past two years in this portion of the James Valley. The swarm was so small that it departed unnoticed.

My collection taken here included numerous specimens of *C. spretus* and other grasshoppers; lepidoptera, neuroptera, diptera and coleoptera were also taken in limited numbers. The lepidoptera were abundant along the river, but were comparatively poor in number of species.

While at Jamestown a rumor was in circulation that locusts had attacked Steele's farm, about 60 miles west of there, and were destroying the wheat, but upon arrival there I found it was a false alarm, and though the locusts were rather plentiful they were not doing damage enough to be noticed, and none had been seen moving in swarms.

July 13.—I arrived in Bismarck late in the evening. On the 14th I learned that no locusts had been seen in that vicinity, and no damage had been reported by farmers during the last and the present years. An opportunity being offered I crossed the Missouri River to Fort A. Lincoln, about 5 miles below Bismarck, and did some collecting in that vicinity. On both sides of the river I found the grasshoppers, especially *C. spretus*, most numerous on the prairie back from the river, while lepidoptera, neuroptera and diptera were most numerous on the low grounds near the river.

July 15.—I took passage on a Missouri River steamboat for Fort Peck Indian Agency, Montana. During the day we stopped at three wood-yards, at each of which I captured a few specimens of *C. spretus*.

July 16.—The steamer wooded once to-day. I did not go ashore on account of the great numbers of mosquitoes.

July 17.—I saw locusts in small numbers at two wood-yards to-day.

July 18.—Passed Fort Buford, but did not go ashore, as the boat did not stop long enough to permit it. However, I learned that the locusts were not troubling them this year.

July 19.—The steamer wooded once to-day. I did not see any locusts at the wood-yard, probably because of the dense underbrush. Arrived at Fort Peck Agency, or Poplar River, at 10.30 o'clock a. m.

While in conversation with Sergeant Brainard of the Second Cavalry,

of Fort Assinniboine, Montana, he stated that they had not been troubled since the post was located, within the past year, but in previous years while campaigning over that country he had found them very thick during the months of July and August in the Bear Paw Mountains and on the elevated plateau circling from the mountains northwestward into Canada.

For favors received while at Fort Peck Agency I am indebted to Major Porter, the Government agent, and Rev. G. W. Wood.

Major Porter reports no damage done by locusts between this place and Woody Mountain, Canada, about 80 miles distant to the north. No swarms have been seen passing over this year. At Deer Tails, 6 miles below, on the river, the crops were in excellent condition, locusts had not been noticed, and I found fewer of them than at the agency on Poplar River.

At Wolf's Point, 25 miles up the Missouri River, Mr. Smith, the sub-agent, reported that no locusts had been there, nor had any flown over during the past two years or since he had been stationed there.

Dr. J. Woodbridge, who has paid a great deal of attention to the natural history of the animals of this section of the country, stated that he had ridden a distance of 30 miles into the Bad Lands, on the opposite side of the Missouri River, without seeing any of the destructive locusts.

Mr. Harry Snell and Mr. J. Williams report having seen locusts hatching in immense numbers in 1876 and 1877 in the Yellowstone Valley, but not many in the past two years.

The agency interpreter stated that he had frequently during the past twenty-nine years passed by what is now Fort Peck Indian Agency, and four years ago he began raising crops there, and in all that time he had not seen locusts in sufficient numbers to be troublesome there.

In 1878 they were seen flying over this place, going toward the southeast. Between here and Fort Buford they have never been known to hatch, by any person whom I have met, but they have been seen almost every year flying over that part of the territory.

Of the collection made here, the principal part was grasshoppers, among which *C. spretus* was quite prominent. Lepidoptera were next. Of this order the genera and species represented were few, although there was an abundance of most of the species taken. Diptera, neuroptera and coleoptera were taken in small numbers. Here, as in other places visited, the orthoptera were most abundant on the higher ground back from the river, while the greater part of the other insects taken were found along the Poplar River bottom.

It is only within the last two or three years that crops have been raised at this agency. Scarcely any one was to be found who could give definite information concerning the locusts.

Returning from Fort Peck Agency to Bismarck, where I arrived August 2, I learned they arrived here August 4, 1878, and remained four days, depositing eggs over a space about 10 miles long from east to west and from 2 to 3 miles wide from north to south. After depositing the eggs they flew towards the southeast. About the middle of August, 1877, the locusts stopped near Bismarck, but did not do much damage. They were seen eating the wild sunflower, which was thought to be an unusual article of food for them.

August 3 I was in Mandan, Dak., and am indebted to Mr. M. Lang for information received there.

In the latter part of June, 1879, locusts were seen flying toward the southeast. Eggs have been deposited every year from 1873 to 1879 along the lower part of the Heart River Valley in quantities to cause

serious apprehensions of danger had there been crops for the locusts to attack. The eggs were generally placed in low ground, rather compact and sandy. The young locusts soon after hatching seemed to be more numerous on the higher ground than on the lower, which was a fact Mr. Lang could not account for, unless they migrated from the low ground. In August, 1878, the wheat crop and garden of a Mr. Fox, near Mandan, was almost entirely destroyed by old locusts. And in the latter part of May, 1879, locusts began hatching on the farm of Mr. Clark, 2 miles from Mandan, in the Heart River Valley, and when their wings were fully grown they flew to the southeast. They were not in sufficient numbers to destroy the growing crops, but injured it severely in places.

From Mandan to the end of the Northern Pacific Railroad, *C. spretus* was found at every stopping place in small numbers. No crops were seen for them to feast upon after leaving the Heart River, some 3 or 4 miles from Mandan.

At Green River, the end of the track, I could find no one who could give me any definite information about locusts in that vicinity. Mr. "Gus" Plumer reported that at his ranche, 30 miles beyond the end of the track, the locusts destroyed his garden in 1878, and in August of that year they deposited large numbers of eggs that hatched the next May and June (1879). But not enough of the eggs hatched to cause him any annoyance. Mr. Plumer could not account for so many of the eggs failing to hatch. The locusts that flew over his ranche in 1878 were going nearly south.

August 7.—Left Bismarck in a wagon going overland to Huron, Dak., about 350 miles distant. The first two days we followed the course of the Missouri River, occasionally going upon the edge of the Coteau of the Missouri. About 10.30 o'clock of the morning of the 7th I saw locusts flying a little east of south, almost following the course of the river at that place. They were very high, but not very thick. About 3.30 p. m. the clouds obscured the sun and I saw no more locusts.

August 8.—Locusts were flying at 11 o'clock this morning, thicker than yesterday, but at a lower elevation. They were going in the same direction, east of south, with the wind, which was blowing a stiff breeze. During the day I saw numbers of locusts rising from the Coteau and by rapidly enlarging irregular circles or spirals join the moving swarms above. Sometimes they rose so numerously as to strike us frequently as we rode along. Many more locusts were seen on the Coteau than on the low ground near the river.

August 9.—Locusts were again seen flying to-day, but more to the east and in fewer numbers than either yesterday or the day before.

The afternoon of August 8 was spent in Fort Yates. Lieut. D. H. Brush stated that no damage had ever been done there, within his knowledge, and that locusts had not been seen flying for the last two years. But I learned that they had been visited by locusts in 1875 and 1876, but the damage done was not great. I myself, as stated above, saw them flying over the fort, but not so thickly as I had seen them while on the Coteau east of the river.

Monday, August 9, the party with which I was traveling turned eastward from Fort Yates across the prairie to the James River, distant nearly 200 miles. Soon after leaving the Missouri we lost the trail and wandered about until near evening, when we struck what afterwards proved to be the Big Beaver Creek and camped for the night. At this place the locusts were quite abundant, as were other species of 'hoppers.

August 10.—We followed the course of the Big Beaver, or rather a parallel course, at a distance of several miles, returning to it in the even-

ing in order to get water. We passed several small lakes, but the water was too strongly impregnated with alkali to be fit for use.

C. spretus and many other species of grasshoppers were taken during the day. Occasionally as we drove into the bottom of a dry lake where the grass was greener and more tender we found the 'hoppers more numerous, and I noticed a few of them when disturbed rise to a height of from 25 to 50 feet, in a few cases much higher, and fly toward the northwest, with the wind, as far as we could see them. In these flights they made no approach to the spiral form of rising, and I think they returned to the ground at no great distance from where they rose. Lepidoptera were scarcely seen; a few beetles were taken.

August 11.—At noon we were rejoiced at finding a trail which one of our party recognized. There was scarcely a breeze stirring, and the heat was oppressive. In the afternoon the horses were attacked by great numbers of flies (*Tabanus lineolus*) and were tormented severely by them. Quite a number of grasshoppers and a few moths were taken.

August 12.—The Coteau was very hilly over the portion we passed to-day. Of the insects captured to-day *C. spretus* bears a smaller relative proportion than in other days. Two species of large 'hoppers, one with coral underwings, the other with sulphur-yellow, were most noticeable. Mosquitoes were plentiful and active in the evening.

August 13.—Descended from the Coteau to the level prairie about 11 miles from the James River. Soon afterward we crossed Elm Creek, and about 11 o'clock we entered the railroad camp on the Chicago and Northwestern Railway grading, about 125 miles west of Watertown. My collection here was mostly 'hoppers, including many *C. spretus*.

August 14.—Passed through Columbia, on the James River, but learned nothing of any locust invasions or flights.

In the afternoon, while crossing the river near York's post-office, we were, through the recklessness of the driver, carried into deep water and treated to an unexpected bath. The valise containing my specimens collected on the Coteau not being water-proof, the specimens were wetted and more than half of them spoiled.

August 15.—Sunday was spent at Slack's stage ranche. The rain fell steadily all day. No locusts have visited this place either this or last year. Mine host was a new settler, and knew nothing of the previous history of the valley.

August 16.—The rain continued falling steadily all day, and no collections were made. Stopped over night in Castleton, but learned nothing definite of locusts.

August 17.—The rain fell steadily until nearly noon. In the afternoon I saw a few specimens of *C. spretus*, but did not take any. Arrived at Huron about 7 o'clock in the evening. I learned that there had been a flight of locusts in the latter portion of July of the present year, going to the south over the railroad grade 30 miles west of here, but I could not learn of any damage done here during the last two years. The town itself is of less than a year's growth.

August 18.—I took passage on the Chicago and Northwestern Railway for Winona, Minn., where I arrived late in the evening. Near Tracey, Minn., I learned there had been several flights of locusts passing south and southeast during July and August, 1879, but they were not numerous or dense.

August 19.—Took passage on a Mississippi River steamboat for Saint Louis, where I arrived August 24, and proceeded home the next day.

Respectfully submitted.

JOHN MARTEN.

APPENDIX VII.

REPORT OF NOTES MADE BY A. J. CHIPMAN.

WASHINGTON, D. C., *October* 13, 1880.

SIR: Acting under your instructions as an agent of the Entomological Commission to make investigations as to the appearance, if any, and the depredations, if any, of the Rocky Mountain locust in Kansas and Colorado, I started west early in August and arrived in Topeka on the 11th of that month. I conferred with the Secretary of the State Board of Agriculture, Hon. J. K. Hudson, and he informed me that he had received no information of the appearance of the locusts within the limits of the State, although in frequent communication with correspondents from nearly every section. I made a personal examination on the hills and plains adjacent to the city, but finding only the ordinary grasshoppers I did not consider it important to preserve any specimens. I stopped over one day at Junction City and made a search for locusts of the destructive kind in the Kansas River Valley, but found none.

At the time of my visit the wheat harvest had been gathered in, and the crop in the eastern section was considered fully up to the average. The corn crop of Eastern Kansas, judging from observations and inquiries made, I consider also an average yield. From Topeka west as far as Salina, on the Kansas Pacific Railway, and west as far as Newton, on the Atchison, Topeka and Santa Fé Railway, from information which I deem reliable, I am convinced that owing to the drought, which in this locality has been severe, not more than half a crop will be realized. In the western portion of the State, throughout what is known as the dry district, great destitution prevails. Many of the inhabitants in about twenty counties are suffering for the necessaries of life. Unless relieved by the hand of charity they must abandon their homes or suffer untold miseries before another season. The inhabitants of Russell and Ellis Counties are not suffering as much as many others, but fully 20 per cent. of the population even there will need assistance. In Ness County the condition of the people is such that fully two-thirds of them must have help. Gove County has lost much of its population, and of those remaining one-half must be fed by the hand of charity. Smith and Decatur Counties are badly off, and a majority of the people will suffer if aid is not extended to them freely. Graham County has suffered by drought, but more from a severe hailstorm, which destroyed the most of what standing grain remained. Rooks County harvested considerable wheat, and will have a fair crop of corn, but still at least 30 per cent. of the population will need assistance. Of the counties I have mentioned I passed through several, and in regard to the others I obtained such information as I considered reliable. That Central and Western Kansas are undergoing favorable climatic changes there can be no doubt. The amount of rain-fall during a given number of years is now far greater than twenty years ago.

was myself a resident of Council Grove for three years prior to the war, and I have now a number of acquaintances who have resided there continuously for twenty-five years. Conferring with them specially on this subject on the occasion of my late visit, I found that their long experiences confirmed my own observations. Various causes are assigned for these climatic changes. One is the disappearance of the vast herds of buffalo, thus making possible a rank growth of prairie grass, which in turn induces a heavier dew-fall. Another is the planting of groves and the successful cultivation of timber. Having been encouraged by State legislation, the planting of trees has become very general. That a greater degree of rain-fall is produced by these causes is the opinion of those who are best informed. I reached Denver on the 18th of August, and proceeded to Colorado Springs on the following day. Dry weather had prevailed here for a number of weeks, but on the day of my arrival a heavy rain fell, lasting several hours. I obtained the services of an assistant for a short time, and made examinations for locusts on the hills east and on the plains south of the village. I obtained specimens of the only species to be found in the vicinity, and preserved them with care. I visited Manitou and obtained and preserved specimens of locusts from the lower hills adjacent to the Ute Pass. I ascended Pike's Peak on the 22d of August and collected specimens at various points on the way. The highest point at which I found the locusts was above the timber-line and one and a half miles from the summit. No locusts of any kind were found on the summit, and I was informed by the officers of the Signal Service stationed there that none had made an appearance there during the summer. On my return to Denver I obtained specimens of the species of locusts found in the fields and on the plains north of the city. I visited Georgetown and obtained specimens of locusts on the adjacent hills. I visited Middle Park, taking the stage at Georgetown for that place on the 26th of August. The route lay over the Berthoud Pass; highest elevation, 11,300 feet. Locusts were taken on the summit and at various points down the western slope as far as Hot Sulphur Springs. I returned to Chicago by way of Cheyenne and Omaha, leaving Denver on the 29th of August. The specimens of locusts collected at the various points I have indicated were carefully preserved and transmitted to you by express from Chicago. I returned to Washington on the 4th of September.

The above report is respectfully submitted.

A. J. CHIPMAN.

Prof. CYRUS THOMAS,

Member and Disbursing Agent of the Entomological Commission.

APPENDIX VIII.

MISCELLANEOUS LOCUST NOTES.

A.—LOCUST SWARMS THAT HAVE ATTAINED THE COAST OF GREAT BRITAIN.

By A. H. Swinton.

Flight of 592?

C. Walford. Journal of the Statistical Society, vol. xli, p. 499. "Locusts with drought."

Flight of 874?

Otho Frisigensis. Liber sextus, caput iiii. Locusts (*cæteris locustis majores* Rad. de Diceto) attempt to cross the British Channel.

Flight of 895–97?

C. Walford. Journal of the Statistical Society, vol. xli, p. 499. "Ireland. Invasion of locusts, and famine."

Flight of 1031?

C. Walford. Journal of the Statistical Society, vol. xli, p. 499. "Locusts and floods; famine."

Flight of 1693.

Philosophical Transactions, vol. 18. "Vast swarms of locusts at Dongelly in Wales and in Pembrokeshire in 1693." (Spec. *Pachytylus migratorius.*)

Flight of 1748.

Gentleman's Magazine for 1748, vol. 18, pp. 331, 364, *description.* Philosophical Transactions, vol. 46, p. 37. Sir Hans Sloan's History of Jamaica, vol. 1, p. 29, "In the neighbourhood of London." M. Edwards, History of Birds (plate 208). E. Donovan, Natural History of British Insects, vol. vii, 1798, p. 49–51, "In Sutherland." Rev. J. Shaw, History of the Province of Moray. (Spec. *Pachytylus migratorius.*)

Flight of 1797?

Donovan, Natural History of British Insects, vol. vii, p. 49–51. "A true migrating locust (*Pachytylus migratorius*) taken at Packington, in Warwickshire, in 1797."

Flight of 1809.

Gardener's Chronicle for Sep. 12, 1857.

FLIGHT OF 1842–1849.

Annals of Natural History for 1842, *L. Christii* visits Leeds, Derby and Sheffield at the beginning of September. The Zoologist for 1843, *L. Christii* visits Derby in 1842; vol. for 1848, *G. migratorius* in England (and Scotland?) during 1846 and 1847; vol. for 1850, "A locust taken at Bristol, Oct., 1849. The Naturalist, Journal of the Yorkshire Naturalists' Union, vol. for 1876–'7, pp. 129–137: Locusts in Yorkshire, by Wm. Denison Roebuck (locusts in Yorkshire in the years 1842, 1846, 1847, 1848, 1849); also the Entomologist's Monthly Magazine for 1870–'71: "At Spurn Point during 1842, 1846. Life of Thomas Edwards, by Smiles, pp. 207–209." "*Locusta migratorius* arrived at Aberdeen, Banff, and Moray in the month of August, and in the beginning of September, 1846, it penetrated to the Zetland Islands, Unst, and the bare and isolated Skerries, becoming a pest in some of the Western Islands." The Entomologist's Weekly Intelligencer for 1857, "*Pachytylus migratorius* at Herne Bay in 1848." (Species alluded to *Pachytylus migratorius.*)

FLIGHT OF 1852–1864.

Zoologist for 1852. *L. migratoria* taken at Redcar in September; vol. for 1857, "*G. migratorius* taken in England, Scotland, and Ireland during August, September, and October;" vol. for 1858, "Locusts in Shetland and Caithness during September; vol. for 1864, locusts in Scotland in September, *G. migratoria* captured in Cornwall during September. The Entomologist's Weekly Intelligencer, vol. for 1858, *G. migratorius* near Hull; vol. for 1859, do. Gardener's Chronicle for 1857, locusts in London and at Great Yarmouth in September. The Naturalist, Journal of the Yorkshire Naturalists' Union, Locusts in Yorkshire, by Wm. Denison Roebuck; vol. for 1876–'7, pp. 129–137, "At Spurn Point during 1858 and 1859." (Species alluded to *Pachytylus migratorius.*)

FLIGHT OF 1868–'69.

The Naturalist, Journal of the Yorkshire Naturalists' Union, pp. 129–137 Locusts in Yorkshire during 1869, Wm. Denison Roebuck. Malta, by Andrew Leith Adams, p. 94. A live locust at Cork, in Ireland, Nov., 1869? The Entomologist's Monthly Magazine, vol. for 1875–'76, Several specimens of locusts taken at Exeter during the autumn of 1869. The Entomologist, Newman, vol. 5, Locust near Halifax at the end of August, 1869, locusts along the coast of Aberdeenshire during the autumn of 1868. The Entomologist's Monthly Magazine, vol. for 1870–'71, *A. peregrinum* at Plymouth in 1869. (Species alluded to *A. peregrinum* (?) and *Pachytylus migratorius.*)

FLIGHT OF 1874–1876.

The Naturalist, Journal of the Yorkshire Naturalists' Union, 1876–'77, pp. 44, 60, 78; 145–150, Locusts in Yorkshire during 1874, 1875, and 1876, Wm. Denison Roebuck. The Entomologist's Monthly Magazine vol. 1876–'77, p. 216, At Spurn Point in 1876, Wm. Denison Roebuck. Science Gossip, vol. for 1877, Locust in Somersetshire in 1874. The Entomologist, Newman, vol. 6, Locust taken in a balloon at Grantham at the end of July, 1873. The Entomologist's Monthly Magazine, vol. for 1875, Locust in North Devon, 25th August, 1875? (Species alluded to *Pachytylus migratorius ?*)

OCCURRENCE OF THE MIGRATORY LOCUST IN JAPAN.

SAPPOW, YESSO, JAPAN.
January 30, 1883.

Prof. A. S. PACKARD, Jr.:

SIR: I send you by this mail a few specimens of the migratory locust of this part of Japan, together with a few of the egg-pods, unfortunately somewhat broken. I fear that the insects are not in good condition, as they have lain in a drawer for some time; but perhaps you may be able to identify the species, and, should you desire it, I can send you perfect specimens next summer. The habits of these locusts seem to be essentially the same as those of the North American species, as described in reports of the U. S. Department of Agriculture, but I should judge that the powers of flight are less in the Japanese species. These insects first (within modern times) proved injurious here in the summer of 1881, when the season was unusually dry, and they left the rather dry and sandy district, which has since been discovered to be their "headquarters," so to speak. In one other respect the habits of this locust seem to differ from those of the American, viz: they often deposit their eggs in quite wet places, places where even in summer water will usually stand in a hole only a foot in depth, and I am credibly informed that the eggs hatch in such localities, though somewhat later.

In the *American Naturalist* for May, 1882, I noticed, in an extract from a letter from Mr. Frank Calvert to the London *Entomologist*, mention of a parasite (*Sarcophaga lineata*) preying upon the locusts in the vicinity of the Dardanelles, and I would like to ask your opinion as to the feasibility or advisability of importing and establishing that or any other parasite upon the locust here. The climate is essentially the same as in Massachusetts, but perhaps three weeks later.

Hoping that you may not deem me trespassing too much on your valuable time,

Very respectfully yours,

WM. P. BROOKS.

NOTE.—Professor Riley has compared these specimens with *Pachytylus migratorius*, and finds that they differ only in being darker and in having blacker and somewhat more sharply defined wing-spots. Köppen, in Petermann's Mittheilungen, 1871, p. 363, records *P. migratorius* from the East Indies, Siam, China and Japan, as well as other points south in the Pacific and Indian Oceans.

B.—EARLY NOTICES OF LOCUSTS IN NORTH AMERICA.

Prof. A. S. PACKARD, Jr.

DEAR SIR: I send you these extracts and the translation from Father Hennepin as contributions to "grasshopper literature." They may be serviceable to you.

Yours, truly,

E. L. BERTHOUD.

[EXTRACT AND TRANSLATION FROM THE FRENCH EDITION, OF 1704, OF FATHER HENNEPIN'S VOYAGE AND DISCOVERY IN NORTH AMERICA OF NEW COUNTRIES AND OF THE MISSISSIPPI (MESCHACEBÉ). EXTRACT, PAGE 34—DESCRIPTION OF FORT FRONTENAC OR CATARAQUI.]

The land which surrounds this fort is very fertile; we have cultivated more than one hundred "arpents" during the two and one-half years I resided there on a mission. Indian corn, European wheat, leguminous plants, potherbs, pumpkins and water-

melons have well succeeded there, although it is a fact that at first our wheat was badly damaged by *grasshoppers. This seems to be the usual rule whenever* in Canada *new land* is cleared—caused, I believe, by the *extreme moisture* of this country.

The first inhabitants that we attracted there fed their fowls upon them.

REMARK BY TRANSLATOR.—It is singular that Hennepin should remark that new clearings always suffered from their devastation, and that the great moisture of the climate of Canada was favorable to them. This is diametrically opposite what we believe is favorable for them, viz., dryness of climate and soil.—E. L. BERTHOUD.

[FROM CAPTAIN SHELVOCKE'S VOYAGE ROUND THE WORLD (EDITION 1723) WHERE HE DESCRIBES THE COAST OF CALIFORNIA, ETC., AND PUERTO SEGURO HARBOR. PAGE 412-413. ANNO DOMINI, 1721.]

Here is plenty of wood * * * but the trees when we were there * * * were so eaten up and devoured by inconceivable swarms of locusts that they gave the country the appearance of a sort of winter, which else could never be observed in this climate. In the daytime these locusts are perpetually on the wing.

C.—THE LOCUST IN CALIFORNIA IN 1880.

LASSEN COUNTY, CALIFORNIA, NOTES.

EDITORS PRESS: I have long been a reader of your valuable paper, and take a great interest in reading it, and it seems to me that every number is better than the last. I am a farmer, and would almost as soon think of doing without a plow as to do without the RURAL. I thought I would send you a few items about this part of the State, but as this is my first attempt, and being a poor scribe, I hope you will judge it accordingly.

This is a very backward spring and summer. Crops are fully one month later than last year. I commenced haying at this date last year, but it will be nearly a month before I can cut anything this year, for timothy has just commenced to head out. It has been a most remarkable season; there has been so much wind that it has dried the ground out, so that after all the rain and snow that fell last winter there will be short crops if we do not have some rain soon. Last Friday and Saturday night we had sharp frosts that did a good deal of damage to gardens, and some say that grain in the upper end of Honey Lake Valley is hurt. The fall-sown grain, which was just heading out, is hurt the most. The fruit was too far advanced to receive any harm. There is a prospect of a large fruit crop this year; blackberries and strawberries excepted, they were injured by the severe winter weather.

I understand that the grasshoppers are doing a good deal of damage to crops in Long Valley, this county. We all have our troubles in some way or other. While the north wind in the lower counties scorches everything up, it brings to us a frost, and perhaps this is a fact that but few are aware of, but it is nevertheless true.

The loss in sheep and cattle was very great here last winter, some losing nearly all by not having hay to feed them. Stockmen are beginning to see that it does not pay to keep large bands of sheep and cattle and nothing to feed them on in case of a hard winter. They may manage to winter on the range for three or four winters without feeding, and then comes a hard winter and the owner loses half, or perhaps all, as in some instances that I know of, and then all his labor and all that he has invested is lost. More anon.

G. R. WALES.

JANESVILLE, *Lassen Co.*

The grasshoppers have appeared at Virginia City, Nevada, flying in armies. The farmers in Washoe Valley state that the hoppers have eaten every green thing.—[S. F. Rural Press, July 10, 1880.]

D.—LOCUSTS AND COFFEE TREES IN GUATEMALA.

Mr. S. B. O'Leary, of this city, has favored me with extracts from a letter written by a relation of his residing on a plantation near Antigua, Guatemala, and containing information about the locust plague, by which lately the crops of Indian corn and a great many coffee plantations in that country have been destroyed. The insect is called Chapulin (*Gryllus miles*, Drury ?), and appeared first in the department of Chiquimula, in the eastern part of Guatemala, close to Honduras. Thence it spread over all the warmer parts of the republic, avoiding the higher and cooler regions. The loss must be very considerable; one gentleman, Don Gregorio Revuelto, in the department of

Suchitepeque, lost in one night 70,000 trees, without there being left one single leaf. In April a swarm supposed to be 4 leagues broad and about 300 metres long approached the estate belonging to the writer of the letter, but fortunately could be partly driven away with noise and smoke.

These facts are interesting, as it has not been observed hitherto that locusts, in such a degree, attack the coffee tree.

A. ERNST.

CARÁCAS, *August* 2.

E.—HISTORY OF LOCUSTS IN OTHER COUNTRIES.

While our own land has been in certain years fearfully scourged by locusts, and to such an extent as would have caused wide extended and disastrous famine and want had the population of the Western States been less active, vigorous and civilized, and with less facilities for railroad transportation, telegraph communication, or less intimate communication in general with the populous centers of the country, it may be safely said that in all probability, should there ever occur such wide-spread invasions and devastation as took place in the Western States in 1867, and 1874–'75–'76, there will not occur even such local distress and partial famine as did occur here and there upon the frontier in those years. We have good reason to believe that the settlement of Montana, the great breeding ground of the Rocky Mountain locust, which is now going on so rapidly, will more than any other cause decrease the number and extent of locust-breeding grounds, and thus lessen the number of those which would otherwise emigrate from the Rocky Mountain region across the plains.

As will be seen by the statements made in the first report of the Commission (pp. 476–477), and by the extracts from different sources given below, the immediate results of a locust invasion are famine, and the diseases and epidemics or pestilences resulting from the lack of food or from the enforced use of bad food. This is particularly the case in the southern portions of Russia, and the semi-civilized region of India, the Philippine Islands, and particularly northern Africa, parts of Algeria, while it is less marked in South America and Mexico. Famine from the invasions of swarms of locusts, on the other hand, is out of the question in regions inhabited by savage tribes. As is well known, the wild Arabs and Bushmen welcome a swarm of grasshoppers or locusts as a season of thanksgiving, praise, and the reverse of fasting; while in the Great Basin of Nevada and Utah, what is now a curse and tribulation to the settlers, was formerly an entomological "rainfall" to the aboriginal Piute and Digger Indian. So that semi-civilization feels keenly the results of the attack of locusts, while a civilized, thickly-settled community, even near the frontier, has within itself the resources for overcoming or so ameliorating the results of the depredations of these insects that it suffers but comparatively little in the long run. As will be seen by our second report, the outcome of the observations and work of the Commission is that the locust plague will be so much reduced in extent and so ameliorated by the rapid settlement of the Rocky Mountain region that we are safe in saying that the best general preventive against the ravages of locusts, the great prophylactic against locust attacks, is the settlement of the permanent breeding grounds of this species.

It is the increase of population in central Europe and the lessening of uncultivated, partly desert areas in southern and southeastern Europe, west of Russia, which has probably put a stop, within the past century, to the arrival of swarms of locusts in Germany and Austria from the southeast.

This process of civilization and settlement of the country in northern Africa, notably Algeria, is apparently thinning out the number of locusts, diminishing the frequency of their migrations, and rendering the frontier settlements less liable to devastation. This is indicated in part by the following extract from an English paper:

The invasion of field-crickets in 1866 cost Algeria 50,000,000 francs, and caused the famine of the next year, in which 200,000 natives died literally of hunger. A single band of these animals, observed in the province of Algiers, contained 50,000 tons of them. This flood of animal matter would furnish a manure containing nearly 1,000 tons of nitrogen. In view of this fact, and the possibility of future invasions, MM. Durand and Hamel have lately devoted attention to finding a means of stopping and burying such swarms, and it would appear they have succeeded. Their cricket-barriers (which are described in a recent number of La Technologiste) are now manufactured and sold by M. Lambert. These barriers are formed of calico stretched on posts; they are arranged not in a straight line, but in lines forming angles, and the crickets advancing to the angle fall into a pit dug there. The crickets are treated in the pit with green vitriol (with a view to the nature of the manure).

THE RAVAGES OF LOCUSTS IN RUSSIA IN 1879 AND 1880.

The following newspaper extracts from Russian correspondents of the English press will show what direful ravages and consequent famine and suffering went on last year and the present (1880) in southern Russia, a region topographically and meteorologically comparable with the Great Plains bordering the eastern flanks of the Rocky Mountains. The heat and drought, the vast extent of grassy "steppes" like our western plains, the semi-civilized, scattered agricultural population, far away from railroad centers, afford a parallel to the frontiers of the United States, only that the people, emancipated serfs and peasants, are far less active, intelligent, educated, and thrifty than our own population, and thus less able to cope with sudden and widespread calamity, or to recover when once stricken down with the terror and dismay resulting from the sudden spoliation of their crops and the loss of every green thing around their homes:

"Turning now from the ravages of revolution to the devastations of locusts—rather a singular transition, you must admit—I find a daily cry of lamentation uttered by all the press of southern Russia. As a very certain proof of how enormous is the damage caused to the crops by this corn beetle, or by what other name the noxious insect may be called, I may mention that in the province of Cherson alone—into the custom-house treasury of which you may remember some days ago the Nihilists digged their underground way and abstracted an enormous quantity of coin—a sum of no less than 50,000 rubles* has been voted for the purpose of exterminating this Egyptian plague. It is feared, however, that the preventive measure will be too late, and that the crops must be parted with in a Christian spirit of submission. On a surface of 300 versts at and around Zanitzin, on the Volga, there has been no rain since the beginning of spring till now, while universal dryness and enormous heat—Réaumur's thermometer standing at 30 degrees in the shade, 40 degrees in the sun—with intolerable sultriness and dust, have destroyed all hopes of the harvest thereabout. The country people, says the *Golos*, are leaving their homes by hundreds in despair and wandering about as beggars. From other parts of the empire, too, the cry of distress is heard, arising from a different chord of woe. The Russo-Polish and Lithuanian towns are swarming with such a large and un-

*A ruble is 75 cents.

employed Jewish population that the civic authorities are no longer able to support them, and the Government has, therefore, resolved to found more agricultural colonies in the various provinces for the reception of this superfluous Hebrew proletariat, those created several years ago having of late shown signs of prosperity—a remarkable truth, I may take the liberty to add, in view of the fact that in no country whatsoever where they settle do the gifted descendants of Jacob show anything but the most deep-rooted aversion from manual labor."—[Berlin Corr. London Times, 1879.]

"During April a shower of these pests fell upon the province of Caucasus, Russia, utterly destroying vineyards and fruit gardens. The village streets were blockaded by them so that the shops were shut up and all traffic closed, while the water-courses were choked by the swarming pests."—[English paper.]

"The Georgian town of Jelizawetpol, near Tiflis, has suffered a plague of locusts almost as bad as that which afflicted Egypt in the days of Moses. On the 20th of April, the insects invaded the town in such numbers that the merchants had to shut up their shops, and walking about the streets was exceedingly difficult. The Russian authorities ordered the inhabitants to make a united effort to kill the pests, but the generous people refused, believing it a sin to destroy a locust, until the authorities threatened to punish every householder who failed to deliver daily a given weight of dead insects. The canals were filled with locusts, so that water for drinking and washing could only be obtained by straining. The houses swarmed with the creatures, and many families went a week without bread because their ovens were literally filled with them. They tried in vain to drive the locusts away by lighting holy candles and burning incense. The Armenian priests regarded the plague as a visitation of God, and brought from a neighboring town the bones of Jacob, which they carried through the streets of the afflicted city in procession, fairly wading through masses of dead and living locusts as they marched along with the relics of the patriarch. The energetic measures taken by the police finally abated the evil, but not until the gardens, orchards, and vineyards had been stripped bare and, the people had suffered for more than a week."—[New York Tribune, 1879.]

"A detachment of Russian troops, bound for General Lazaroff's expedition against the Turcomans, met with a curious misadventure near the Georgian town of Elizavetopol. At a few versts from the town the soldiers encountered the wing of an army of locusts, reputed to be twenty miles in length and broad in proportion. The officer in charge did not like to turn back, repelled by mere insects, and, pushing on, soon became surrounded by the locusts. These appear to have mistaken the soldiers for trees and swarmed by thousands around them, "crawling over their bodies, lodging themselves inside their helmets, penetrating their clothes and their knapsacks, filling the barrels of their rifles, and striving to force themselves into the unfortunate men's ears and noses." The commander gave the order for the troops to push on double-quick for Elizavetopol, but the road was so blocked with locusts that the soldiers grew frightened, and, after wavering a few minutes, a regular stampede took place.

"Led by a non-commissioned officer of keen vision, who had observed a few huts a short distance from the road, the troops dashed across the fields, "slipping about over the crushed and greasy bodies of the locusts as though they had been on ice." The huts were soon reached, and the officers rushed inside, but the refuge proved to be of little value, as the

premises were already in possession of the enemy. The peasants told the correspondent of the *Kavkas* that for days they had been besieged by the vermin, the insects filling the wells and tainting the water, crowding into the ovens and spoiling the bread, and preventing any food being cooked or stored. At intervals the villagers issued from their houses and made onslaughts on the locusts, killing them by thousands, and carting them away afterwards to the fields for manure. The soldiers were detained prisoners by the insects for forty-eight hours, and on their march to Elizavetopol in the rear of the locust army they found every blade of grass and green leaf destroyed and the peasants reduced to beggary."—[New York Tribune, 1879.]

"HINT TO WESTERN FARMERS.—Mr. Hoffman, chargé d'affaires at St. Petersburg, in his dispatch to the Department of State, dated September 16, sends copies of an official report on locusts. It appears that the grain locust of Russia generally deposits its eggs in the wheat fields, and that as soon as they are hatched the attack on the wheat commences. The use of ropes and machines to drive the locusts from the wheat fields is not advisable. It is better to plow the ground where the eggs are laid, as ten minutes' exposure to the sun kills the chrysalides. The prevalence of locusts in southern Russia has been, by these latter means, greatly reduced, so that good crops of wheat may be expected in 1881. Possibly some lessons may be derived from Russian experiments and reports affecting American grasshoppers.

"The losses, and consequent alarm and famine, again prevailed in 1880, with nearly the same story of threatened consternation, hunger, and poverty among the Russian peasantry."

"LONDON, *May* 8.—The St. Petersburg correspondent of the *Standard* says the beetle which ravaged the crops in Poltavia and Ekaterinorslau in 1878 has been found in large numbers in a larva state, and the peasants fear to sow spring crops. The same correspondent says the greatest alarm prevails in Tiflis in consequence of the discovery of locust eggs. Unless exterminated before final development, a famine throughout the Caucasus is inevitable."

"ST. PETERSBURG, *July* 8.—The *Golos* raises its voice, in view of the Chinese difficulty, to point out the sad condition of the country, and how much worse it will become in the event of another drain upon its already exhausted resources, and retarding the introduction of reforms. The press for several weeks has been full of complaints of ravages by locusts, flies, beetles, and worms, hunger and poverty among the peasantry, a rapid increase in prices of everything, increase of the cattle plague, a large spread of disease, &c."

A recent number of the *Golos* contains an interesting letter from Tiflis describing the enormous labour bestowed during the summer upon the destruction of grasshoppers. The work was carried on for about three months, and occupied in one district (Gori) no less than 20,000 people per day. More than half these people had been summoned from the neighbouring districts of Achalzych, Ossetia, and Imeretia. Thanks to the colossal efforts thus made, only 2 per cent. of the total crops of the district were destroyed by the grasshoppers. Many million roubles worth of hay and corn were saved by this work. On the other hand the organisation of the whole cost the Russian Government some 200,000 roubles, and many thousand acres of fields and gardens have been utterly neglected by the population to whom they belong.—[From "Nature" of December 16, 1880.]

The Russian newspapers report that much mischief is being done to the crops in South Russia by locusts and other insect pests. In the district of Rassachs an area of over 400 kilometers has been devastated

in this way. Upwards of 5,000 men were daily employed in the work of extirpation, fully 8,000 kilograms of locusts being gathered every day. On the road from Tiflis to Poti the locusts lay so thick on the line that the trains were obstructed. The Vedomosti says that the steppes of the Don have been swept bare of all vegetation, as if a fire had passed over the land. Fourteen companies of soldiers are employed in the Odessa district in destroying these insect plagues. A huge swarm passed by Moscow in the middle of June, at an elevation of from 70 to 100 feet.

LOCUSTS IN CHINA IN 1878.

While in past centuries this thickly settled country has been ravaged by locusts, as shown in our first report (p. 477), it appears that they still abound, notwithstanding the dense population, though they apparently breed in desert places and invade the more populous areas. It appears by the following extract from a Chinese (English) newspaper that locusts abounded in great numbers in eastern China on the lower Yangtsze River, and it likewise appears that the natives initiated the use of oil on streams and likewise scattered over dry fields, and found it to be one of the best means of killing these pests. It thus appears that the Chinese, when hard put to it, can take up and put into practice new remedies. From the second account of Chinese methods of exterminating locusts, by a foreigner, Mr. K. Scatchkow, for many years resident in China, it appears that locusts periodically ravaged the country; though whether the same region or not, does not appear. We reprint these interesting statements, being of very general interest:

Locusts on the lower Yangtsze.—Major Yao has received from Brigadier Fan a proclamation issued by the Viceroy Shen to the effect that last year flying locusts covered the countryside, leaving behind innumerable grubs which soldiery and local officials were then instructed to search for and dig up. From that time up to the present over two millions catties have been brought in, thus proving there has been no lack of energy in obeying the orders given, nor any deficiency in the numbers given up. Reports are now crowding in that locust grubs are springing up like ants and flies all over the countryside, that they are big enough to hop about and will in the twinkling of an eye have wings and commit unutterable harm. Mr. Brigadier Woo has now discovered in course of his literary researches that locusts have an instinctive dread of oil. He has therefore instructed his braves to mix a picul of oil with water and scatter it over locust-infested fields, whereby the insects would be killed. In fields where the rice is just sprouting, the oil floating on the water will prevent the descent of the locusts. Oil from the Elæococca tree, however, is injurious to the crops, and should not be used, but every other kind of oil is equally destructive to locusts, hemp oil being the best. The Viceroy has noticed, too, in a certain work, that locusts dread oil, and that it is the best preservative for the crops. Facts like these about oil cannot be too widely known, in order that men by their personal efforts may second the desire of Heaven for harmony (aide toi).—[North China Daily News.]

THE EXTERMINATION OF THE LOCUST IN CHINA.

In one of the scientific meetings of our Entomological Society the question of the calamities from locusts, and the different ways of exterminating this insect, have been discussed. But I think that our entomologists do not yet know the Chinese way of this extermination. Wishing to fill up this deficiency, I have hunted up in the large Chinese bibliography Sy-koo-zuan-shoo-moo-Eoo nearly all the names of works connected in any way with this question, but have found only three which have entered more or less into particulars: (1) Zsu-hooan-ho-min-book about salvation from starvation, written by Doon-vey at about 1100 after Christ, and soon afterwards corrected by Van-bin. (2) Zsu-hooan-ho-min-shoo-boo-ee-book about salvation from starvation, corrected and amplified; it has been written in 1442 by the learned Tjoo-soon-vey-zsy,

on the programme of the above-mentioned work of Doon-vey, with the exclusion of all that is not quite connected with the subject and the addition of some new facts. (3) Poo-hooan-kao, on the extermination of locusts, written, on the example of the preceding work, by Tchen-van-shen, as a separate pamphlet or in the collection Hooan-tchen-zoon-shoe, collection of regulations against famine, published in 1690. Of these three works I possess the second in the newer edition of 1518. Though this book is already four centuries old, its author is still very popular, and the book is even now a *vade mecum* of every official in China who has anything to do with the question. In its twelve chapters all misfortunes from poor harvests, want or excess of rains, locusts, and other losses which we have to encounter, the Chinese are very well informed about, and they have proposed a quantity of ways to prevent these calamities.

The same ways of exterminating the locust of which Tjoo-soon-vey-zsy speaks are at the present day used in China. Considering that his book is four centuries old, one wonders that the Chinese should not have found something newer and better since; but, on the other hand, one cannot help admiring them for obliging their superstitious brothers to exterminate the locust so long ago, when even in our day one has so much trouble to make some Russian and West European peasants do it. I have several times in China seen invasions of these insects, and have noticed that every Chinese countryman now does his utmost to exterminate them, though he still considers their coming to be a punishment sent by Heaven. The following is a translation of the ninth chapter of the above-mentioned work, as far as it speaks of the extermination of locusts, with some explanations:

"It is said that during the reign of the Tan dynasty the Emperor Taï-Tzoon (dynasty Tan from 627 ante till 649 post Christum) swallowed a locust and Tao-Choon exterminated locusts. Some people laugh at that, and say that we want to be cleverer than Heaven, going against its will. I don't think so! We know that the misfortunes which come over us are of different natures. One can take means against some of them, while all human power is useless against some others. So you have to bear patiently excess of waters, of early frosts; but you have watering engines against dryness, and you can get rid of locusts by exterminating them. It is possible that there should be no means against such a calamity. The local authorities must take care of the people, and must also make them understand that they have to protect themselves against such kind of misfortunes. Once, the governor of a district, knowing that locusts do not eat shoots of peas, when the locusts came gathered a quantity of seed of field peas and persuaded the country people to seed nothing but that on their fields; the consequence was that not only the locusts did not eat anything, but the next spring the people had some profit. (I have to beg the reader to excuse the author for repeating this old story. If he believed that locusts do not eat pea-shoots, one would only have to advise never to grow anything but that on the fields visited by locusts. The Chinese believe that in ancient times there were in everything examples of luck, order, and knowledge.) That is the way they acted in ancient times. We see in the chronicles of the Emperor Shen-Tzoon's reign (dynasty of Soon, reigned from 1068–1085 T. D.), in 1075, he ordered that the district governors and their assistants should be personally present at the places where locusts were expected to appear; and in case the invaded country is large, that the younger district officers should be also ordered thither; they and the village chiefs were obliged to invite the people to gather the locusts. For five shens (one "shen" Chinese measure contains nearly 25 cubic inches) of larvæ of locusts, or for ten shens of locusts, the gatherers received one shen of fine millet, and for one shen of locust eggs two shen of coarse millet, or they could also get the corresponding price in money. After that the officers and village chiefs had to burn the locusts. If any one had his crops eaten up he was freed from taxes on the property for one year, and was rewarded, in correspondence with his losses, with money, but not exceeding the value of a hundred moo of land (one moo is a Chinese square measure about 132 square Russian sageens, or about 135 square fathoms).

"Such was the very efficient way of exterminating the locusts during the Soon dynasty. But, though this method may be very good, indeed, I think, however, that one can exterminate this insect directly after its appearance. Generally villagers get frightened at the arrival of those insects, worship them, sacrifice to them, and do not dare to exterminate them, and therefore never can get rid of them. They never hear of the contest of the times of the Tan dynasty, between Minister Tao-tchoon and his colleagues, Neejo-Shoeï and Loo-Hooaï-Tchen. I will tell about it, and in case locusts should appear anywhere my story should be promptly published and distributed for public information, that the old and learned people may explain it and teach the commoners. The fifth year of Uan-tzeon's reign (716 T. D.) when the district of Shooan got infested by locusts, and the inhabitants were beginning to sacrifice to them and gave up to them their crops—not daring to catch them, the Minister Tao-tchoon said to the Emperor 'to capture there those brigand insects and deliver them to the flames.' This expression was a quotation from an ancient poem about the destruction of locusts. Though an officer had been sent, therefore, to the district Tian-Djou, and was preparing to fulfil his duty, the local governor, Neejo-Shoeï, told

the Emperor that one should escape this celestial punishment by doing good, and reminded him of Loo-tzoon, who had not succeeded in destroying the locust, and had by that dragged his country into greater trouble. Tao-tchoon answered him reprovingly: 'Loo-tzoon was a prince-usurper, and his virtues did not surpass his falseness; now baseness does not surpass the virtues; in ancient times the locust did not approach places where the commanders were good men, and now one advises to look, without doing anything, at the destruction of the crops, and who is the man who advises this—the local chief!' Neejo-Shoeï got frightened at this speech, and took to the destruction of the locust, and gathered 40,000 dan of it (1 dan is 100 shen). But some men condemned the minister, and did so much as to influence Uan-tzoon, who also began to doubt whether the minister was right. Tao-tchoon said to the Emperor, 'One cannot change stupid scientific men nor pedantic books; though we cannot get entirely rid of the locust and the evil they bring, it would still be better to destroy them than to give up one's self to ruin.' Uan-tzoon was satisfied with this answer, but the minister's colleague, Loo-hooaï-chen answered: 'Can human power do anything against a celestial punishment? From the destruction of too many of these insects the equilibrium of the elements must be injured.' The minister answered him: 'In ancient times Prince Djooan-Uan swallowed an insect and was cured from an illness. Shoe-Nao has cut a snake in two and luck never left him after that; and now with the locust luck can also speedily return; and if we do not do something against this insect the crops will be destroyed. In destroying the locust we save men. All the responsibility for this shall fall on me, and not on those who but execute my orders.' Very soon after this distress from the locust entirely ceased."

REGULATIONS REGARDING THE EXTERMINATION OF LOCUSTS.

(a.) *Orders published under the reign of the Emperor Shen-tzoon:*

1. Wherever locusts appear, and the landowners or their neighbors conceal it, and the elders don't take measures for its detruction, each of them will have a hundred blows of a bamboo rod. If the local chief, having been informed of the arrival of locusts, should do nothing against them, or not be personally present at the execution of measures of destruction, or not having destroyed all the locusts, inform wrongly the Government of having destroyed them all, he will be liable for each of those offenses to the above said number of bamboo-rod blows and to twenty additional blows.
2. Whenever locusts leave desert places to go to populated ones the local chiefs are obliged to hire poor people and have the eggs destroyed. If all of them should not be destroyed and the locust therefrom reappear the next year those commanders will be punished with 100 bamboo-rod blows.
3. In the villages where the locust passes and leaves eggs the landowners and elders will be punished in the same way for the imperfect destruction of those eggs.
4. If the measures of the corn distributed as pay for such labor should be intentionally smaller than due, the punishment would be equal to that received by officials in villages for taking bribes, concealing Government property, or appropriation of strange property.
5. If commanders in places overrun with locusts would appropriate to themselves strange preperty they would suffer the punishment of those receiving bribes from convicts placed under their care.
6. During the presence of locusts the local commander will always be responsible even if he should be at the time absent on duty—as long only, however, as it will be within the limits of his district.

(b.) *Manners of destroying the locust.*

1. Every morning at sunrise the locusts creep up the stems of the corn and strong grass so as to drink the dew; at that time they are heavy and can neither fly nor jump. At that time one must drive them with sticks into baskets and from there put them into bags and then burn them on fire or pour some boiling water over them or dig a hole in the ground, make a fire inside, and throw them in it. Everybody knows that it would not be sufficient to simply bury them, as they could creep out through the small holes in the earth.
2. Locusts don't die easily. In knocking with a stick on a fresh larva one not only would not kill it, but would also destroy the crops. Old leather or even grass soles would do much better. One must put the sole on it and press it with the hand against the ground. This would keep the corn unbroken. Out of one bull's skin one could make many a sole, and give them to keep to the elders for case of need. One says such method is used in Mongolia.
3. If the locusts are on an open, free place, one must dig a ditch across their way in front of them. The larger the ditch is the better. One must cover the ditch with

boards and make a door (double folding) in the center. A lot of men must drive the locusts into the hole with branches and shouts, and some others stand near and brush them in with brooms. If they try to get out again drive them back. Once filled with the insects the hole must be covered up with dry grass and fire put to it. However, even after that some of them will be alive at the bottom of the ditch. For that purpose one will have to bury the whole thing and trample on it. And do the same the next day. One could also make a fire in the ditch beforehand and drive the locusts in afterwards.

4. Once the locust appears there is no writing to be done for excuses of absence of chiefs, &c.—paper won't help—the commander-in-chief must be present. The servants following the chief in those cases must not clean out whatever valuables, &c., they find at the elders, like silk worms, as the elders would afterwards pay themselves on the villagers. In that case, not seeing yet the good consequences of the destruction of the locusts, they would only see the evil accompanying that destruction. One cannot admit that.

5. As soon as locusts are noticed in the neighborhood of a town, bills must be distributed describing the way to destroy them and notifying that one shen of corn will be paid for each ten shen of locusts at sight, whoever may bring them, woman or child. In doing so one can destroy all the locusts for miles around.

6. Five houses form a precinct. Its elders must teach its inhabitants the usefulness of the destruction of locusts. A great thing is that the bread in store and money should not be spared as pay for locusts. Then the destruction of locusts will find working areas in the neighborhood and will progress surely, if not quickly. The exactitude of payment is indispensable, as otherwise men would abandon the work. The Government corn store belongs in principle to the people. If the locusts destroy the crops the people will suffer from hunger. Judge if it is not better to give the bread to the poor in exchange for locusts than to have it rotten in store or eaten up by mice or sparrows.

7. For the purpose of burning the locusts one digs a ditch of 5 feet deep and 5 wide (the Chinese foot is nearly equal to the Russian one) and twice as long. One empties the bags into the fire. As soon as the locust is in it, it won't jump out. That's what the poetry means by "delivering them to the flames." Even in old times they knew that if you bury a locust he will creep out again. Therefore the destruction of locusts by fire, as they did in ancient times, is the best.

These methods are really not very humane, but if you avoid the destruction of locusts you will have to forget the welfare of the people; which do you think ought to be thought of first? Was not therefore Tao-choon wise and good when he said, "in killing insects one saves men." His acts proved his wisdom.

K. SCATCHKOW.

LOCUSTS IN CAPE COLONY, SOUTH AFRICA.

Nearly all the books of South African travel speak of locusts as emigrating in vast swarms in southern Africa. The following article shows that of late years they have periodically invaded the settlements, and that the people there have had nearly the same experiences as on the the frontiers of our country. The article appeared in the Cape Monthly Magazine for March, 1879, over the initials C. S. O.:

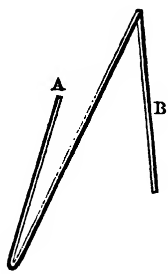
"For some years the locusts have not been troubling these parts of South Africa, but probably they will make their appearance again before long. Since my arrival in South Africa in 1843, I do not remember having seen any but flying locusts till 1854, when the marching locusts ("voetgangers"—infantry), those which have not attained to wings, appeared in the Colesberg district of Cape Colony and the country now known as the "Orange Free State." The locusts then destroyed the country before them, leaving in their rear a desolate wilderness. They marched uninterruptedly through the village of Colesberg, over walls and houses, and destroyed every green thing. The plague lasted for weeks, and until the insects obtained wings, when the winds soon wafted them away to devastate the lower country until

the ocean received them. Any opposition seemed so hopeless that none was attempted. I had seen in previous years the devastation caused by the flying locust. Farmers then made attempts to keep the locusts from alighting on cultivated lands by making fires to windward of the crops, and casting on the fires damp weeds to cause a smoke. This mode of defense was always very feeble, and often wholly useless; and the standing crops, it might be of eared wheat, were leveled and devoured in spite of all that could be done. The flying locusts are a favorite food of the natives, and, I may say, of the remainder of animal nature, as every creature preys upon them, from the elephant to the ant. A flight of locusts settles down pretty closely at nightfall; and they do not, on cold mornings, rise till the sun is well up and has warmed them. If they settle for the night near a native village, the population turns out early, and if branches of trees are to be obtained the locusts are swept together into heaps, and from thence put into bags for conveyance homewards. Locusts are not bad toasted on hot ashes; but the usual way of cooking is to cram them into a pot containing just enough water to steam them over the fire; they are then thrown out to dry in the sun, and then the wings and legs are removed by brushing the locusts backwards and forwards with a small bush. Locusts are esteemed the most when they are full of eggs. I have often been offered dried locusts, either whole or in coarse powder, at native kraals, and have often partaken of them and made a good meal.

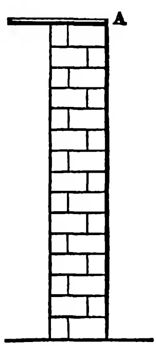
"Later on, in about 1863, we in the Orange Free State were terribly taxed with the locusts, first with the flying locusts, which left eggs behind them, and then, after the rains hatched the eggs, we had continued attacks from the young. It was in about 1863 that I noticed that the marching locust could not climb up to the top of a sheet of corrugated iron laid on side against a wall. Every imaginable device was brought into play against the common enemy, but this town had to give in, and it was more than once swept clear of all green things. The whole population turned out from time to time. Rows of people with flags kept waving were employed, but to no purpose. The locusts, at first somewhat tractable, became wild and broke through our lines. I collected some wagon loads of old thatch and took some hundred Kafirs to attack the enemy in the open outside of the town, laid the thatch in a long row in heaps, got the locusts driven on toward it, ignited the thatch and destroyed millions, but still as many millions escaped and remained behind to destroy. I thought some stench might cause the insect to turn aside. I tried paraffine, by trailing long pieces of old crape soaked in the oil in front of the invading army, but whether the paraffine was ignited or not, it made no barrier worth speaking of. However, having noticed that the locusts cannot climb up a sheet of corrugated iron, I made a few experiments with tin, and found that a wall could be effectually armed against all attack by locusts with a strip of tin, say 2 or 3 inches wide, nailed, say, flat against it. I thus continued to think the matter out and to satisfy myself by a few experiments. It is plain that if all marching locusts are killed there will remain none to get wings and fly, and if there be no flying locusts there will be none to lay eggs. Of course, however, while there is back country uninhabited, it will always remain possible that there locusts may breed and come flying to us, but still much damage could be prevented by destroying the young which appear in our midst. I fully satisfied myself that all swarms of marching locusts could be attacked and destroyed, and having so satisfied myself I communicated my convictions through the newspapers to the public. I have continued from time to time to publish

my convictions, but all my trouble has been of very little effect, for the country has been repeatedly swept of all verdure by the scourge. At one time the Queenstown people suffered much from locusts, and a draft bill was framed there to lay before the Cape Colonial legislature. The draft act was to enable fines to be levied upon those proprietors of farms who should fail to destroy the locusts which should appear upon their properties. In the *Cape Argus* I attacked the views expressed in the draft bill, and showed how the locusts could be assailed and destroyed effectively, and pointed out that the population, as far as need be, ought to be called out to the assistance of those unfortunates upon whose properties the young locusts should appear. The draft bill, I think, was not brought forward in the Parliament. I, having recognized that material for assault would be needed, should the farmers desire to test my plans, twice addressed mercantile houses at Port Elizabeth, explaining my views and suggesting that they should import tin plates cut into strips of 3 inches breadth and 6 or 8 feet long, in boxes, say, of one hundred sheets, for sale to the farmers. Nothing came of this. In a subsequent year one Dutch farmer, in the district of Fauresmith, when the marching locusts came again, went to his district town and begged from the shopkeepers the tin linings of packing cases, which are generally thrown away. He got a quantity, cut it into strips, armed therewith his walls, and while every other farmer in the state almost lost all his crops, he saved everything. My suggestions had probably been communicated to him. Later on still I satisfied the member of the Volksraad for Bethalie about the effectiveness of tin arming, so that he saved his gardens. He brought the matter before the Volksraad, and that body, on his motion, voted £100 to be spent in the purchase of rolled sheet zinc in Belgium, under condition that the metal should be resold to Free State farmers at cost price, to enable them to provide armor for the walls of their cultivated lands. I would have advised in favor of tin instead of zinc had I been consulted, as tin would maintain its straightness better than zinc. However, the zinc has to this day never been ordered, and the next visitation will find no one prepared. The plans which I had brought forward included measures for hostile attack upon young locusts from the time of first appearance in the size of house-flies, or smaller, to final extinction. The last appearance of young locusts found no one prepared. The district of Rouxville was attacked. My brother-in-law, who had repeatedly heard my explanations regarding defense and attack, lived there, and he, from Rouxville and Smithfield, got all the tin linings of packing cases which could be procured. His cultivated lands were open on one side, and thus wholly exposed to attack. On this side he dug a trench of about one foot deep, and heaped up the soil thus obtained on the inner side. He cut up the tin linings into strips of about one foot broad, joined them together with rivets, or otherwise, and inserted the joined strips into the heaped-up earth. Not a locust got into his land. He next adopted offensive measures, as I had advised. He joined a few strips of tin together, making two long strips of, say, 30 feet each, and with the assistance of a few natives placed these upright by leaning them against some wooden pins driven into the ground, and thus formed a funnel-shaped alley, or an alley in the shape of a truncated V in front of an advancing swarm, and provided a hole in the ground with perpendicular sides, at the narrow end of the alley. He then, with his assistants, *gently* drove the swarm into the ever-narrowing alley, the whole swarm pressing on and taking the fatal leap into the excavation. Thus at a distance from his cultivated lands he completely destroyed

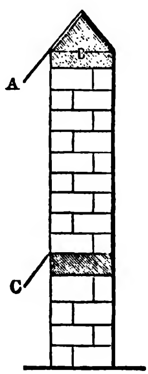
swarm after swarm, and saved a great part of the district besides his own crops and pasturage. The killing of the locusts was effected, as in Rajpootana, by covering those collected with earth and stamping the earth down. I believe that glazed earthenware tiles would form an effective armor for walls. To some rough walls metal could not be affixed flat, and for that reason, and also because it would be well, as soon as the plague is over, to remove the metal and pack it away for future service, I suggested that blocks should at certain distances, about 7 feet (if the tin strips should be 8 feet long), be built into the walls, so that staples could be inserted into them to support a contrivance of iron, shaped like the following diagram, B to be inserted into the staple,



A to support the ends of two strips of the 6 or 8 feet tin, the fold between A and B to be 3 inches long. The staple and block would remain in the wall, and the iron contrivance of support for the tin and the sheets of tin could safely be stored away after use. The tin would thus be safe from theft, and damage from cattle rubbing against it. I calculated that the last swarm we had in this district of marching locusts, then pretty large already, would have formed a column of one yard square and 20 miles high. I am fully satisfied that a force (not at all numerous) should be called out to attack marching locusts when they appear, and that a very small force with a few strips of tin would destroy any invasion of locusts.



Section of wall. A, glazed tile.



Section of wall. A, the sloping tin strip. B, the block. The sloping tin strip would act just as well at C.

The tin being placed in a projecting position would add to the difficulty of a locust passing over it, or rather would wholly prevent its ascent.

"Locusts after obtaining their full-sized wings begin to pair; the male dies early, the female flies until ready to lay or deposit her eggs. She bores her tail into the ground till all that remains of her above ground is her head, shoulders, and wings; her body then breaks off, the eggs remaining in the natural sheath. The young locusts do not appear until rain falls, rain seemingly being necessary towards hatching; but then there must be, apparently, a favorable season also, as it is believed that eggs remain in the ground unchanged for years, although rains fall. Boers have told me that one rain sometimes only vivifies some of the eggs of one individual, and that the remainder of the eggs only are affected by a later, more penetrating rain. Where the country is open, and there are hills to ascend to observe from, the congregated swarms of young locusts are easily, at early morn, perceived at a distance, at first in black and afterward in brownish patches, as each swarm congregates together at night. In marching the locusts advance with one or more points, so that it is easy to lay a trap for them to walk into, and the less they are disturbed by driving the better. Young locusts cast their skins at least twice before they obtain wings."

C. S. O.

SMITHFIELD, *January* 1, 1879.

The best mode of protection against flying locusts must greatly depend upon the state of the wind and the nature of the locality. When chased by the different kinds of locust-birds they endeavor to evade the birds, so it is useful to imitate birds by attaching strips of white calico, like wings, to lines stretched between poles, and to keep them fluttering, either by hand or by the force of the wind.

Telescopic poles for the lines would probably be of much benefit, as probably therewith the locusts would rise high and pass over the crops. Numerous small kites, if there was wind to support them, or small balloons to support high lines, would also be useful.

The above cutting from a late number of the Empire shows that locusts have lately been troubling Razpootana, and I see by the last papers that the same scourge has been devastating in the Philippine Islands.

LOCUSTS IN THE PHILIPPINE ISLANDS IN 1878–'79.

In our first report some account was given of the recent appearance of locusts in these tropical moist islands. It appears by the following newspaper extract that the distress was renewed in 1878 and 1879:

The Philippine Islands are experiencing a severe drouth, which is aggravated by the ravages of locusts, and there is great suffering among the people, many of whom are obliged to subsist on roots.—[Journal, Nov. 23, 1878.]

THE LOCUST PLAGUE IN BOLIVIA.

NEW YORK, *June* 26.—Panama advices of the 17th state that much destitution exists in Bolivia owing to the destruction of crops by locusts—1882.

LOCUSTS IN INDIA.

Next to southern Russia, India is afflicted most by the ravages of locusts, and the matter has been investigated by Government petty officials, though not by scientific men.

A dispatch from Calcutta reports that the Government of Madras has telegraphed for extra famine officers immediately because of the ravages of the locusts.—[Newspaper, 1879.]

LOCUSTS IN INDIA IN 1878.

[From the Revenue Report of the Government of Madras, 1878.]

NANGUNERI, *February* 9, 1878.

The plague of locusts has gone on increasing and very great damage has been done, especially to the cumbu, in the Ottapidaram Taluq, and also further north.

The first intimation of this new disaster was from the neighborhood of Tattaparai, a station on the railway, a few miles south of Ottapidaram itself. They were then moving westward, accompanied by a vast army of a kind of reddish-brown grasshoppers, which, it has been conjectured, are merely locusts in a preliminary stage of existence, and which at any rate consumed every leaf of cumbu as they moved slowly along, and probably a good deal of the grain. They progressed so very slowly that it was many days before they reached Maniachi (a little more than a week ago), and now they appear to be following the line of railway to the north, though a considerable number were reported to have been seen nearly as far south as Gangaikundan, within 10 miles of Tinnevelly; and reports of their arrival in scattered detachments in other parts of the district also have been heard, but fortunately not as yet amongst the rice crops in the Tambrapurni Valley.

No one seems to have any idea of their origin; and it is equally dark as to their destination, or the probable duration of their stay in the district.

Fortunately, the bulk of the dry crop in the north had been harvested before their arrival, and as the rice harvest has also begun, hopes are entertained that they will be too late to get any share of it even if they come at all.

The most anxious question at present is whether they will eat cotton when there is nothing else left. So far they appear to have left it alone, but then there has been abundance of more nourishing food to be got, and the owners of an unusually fine crop of cotton are naturally suffering terribly from suspense.

No one seems to have attempted to destroy or get rid of them in any way; but a good deal of grain was hastily picked (probably before it was quite ripe) as the plague moved on.

J. B. PENNINGTON,
Collector of Tinnevelly.

SATTUR, *February* 7, 1878.

Locusts appeared in swarms in the village of Sattur and in the fields adjacent to it this morning. They have been also going towards the western hills, and it is feared they may damage the paddy cultivations now in a thriving condition in many of the hill villages in Sankaranainarkovil and Strivilliputtur.

In a few fields on which cotton is cultivated the locusts appeared largely. They simply crawl on the ground and one or two fly about the stalk and do not appear to destroy either the leaves or blossoms. However, it remains to be seen whether they eat the cotton as they do the cumbu or cholum.

H. SUBBARAYER IYER,
Acting Deputy Collector of Tinnevelly.

Proceedings of the Madras Government, March 20, 1878.

The attention of the Governor in Council has been drawn to the frequent notices of the flights of locusts in the reports of district and other officers, but which have been unaccompanied by any clear indication of the direction of flight or the first known gathering or resting places of these insects. The Governor in Council desires, therefore, that district officers will impress upon all sub-collectors, assistants, deputy collectors and tahsildars that the Government attach much importance to accurate information as to the movements of these insects being communicated to them; and the care with which this information is obtained may very materially affect the success of any measures which may eventually be found necessary for their destruction or to check their ravages.

C. G. MASTER,
Secretary to the Government.

OODOOMULPETTA, *March* 26, 1878.

On the 21st and 22d instant, between 12 m. and 2 p. m., a swarm of locusts made their appearance in the Kullapurum village of this taluq, apparently having come down from the Anamallay Hills. They completely, or nearly so, destroyed the paddy in Karoongalpathoo (one of the divisions into which the nunjah lands of Kullapurum are divided). On being driven from there by the ryots, the locusts entered the nunjah lands of Ramakolum, belonging to Comaralingum village, and destroyed the paddy crops in about 40 cawnies of land, the produce of which was estimated at about 300 salagayas, or 24,000 pucka measures.

Leaving this they betook themselves eastward, passing through Kolumam village, where they also destroyed some paddy. They finally entered the Pulni Taluq (Madura district).

The total damage done by these locusts has been ascertained to be worth about Rs. 4,000.

The swarms were described as being about one mile in length and three-fourths of a mile in width, and as they passed they completely hid the sun from sight.

J. H. COOK,
Special Assistant.

ARNI, *May* 10, 1878.

The following suggestions are from J. F. Price, esq., acting collector of the Chingleput district:

When in Cuddapah I carefully considered the subject of the best way to deal with incursions of locusts, and was unable to arrive at any satisfactory conclusion as to how to meet the difficulty. I suggested to the people using nets and beating the locusts into them, but was invariably met by the objection that this was impossible.

I consider that offering rewards for eggs would produce no results. Indeed, it has not yet been shown that these pests breed here at all. The conditions of Europe and America are such that there is not much difficulty, when the energy of the European

race is aided by the small extent of country in which the locusts can lay their eggs undetected, in doing something to put them down. Here, however, everything is against this. Patches of uncultivated country, of greater or less extent, are to be found almost everywhere; the people want energy, and are so wedded to their own ideas that they will try nothing that is suggested to them.

I believe myself that with a fine mesh-net so made as to bag in the center, and put across the end of a field attacked by locusts, the insects might easily be beaten into it and destroyed; but it is hopeless to expect natives to do this kind of thing. It must be under the superintendence of a European; and thus the crop at stake will cost more than it is worth.

Protecting fields with fires, or destroying locusts by this means, is a measure which cannot be effected in southern India. The spots where I have in Cuddapah seen the locusts doing the most damage are those where there is hardly enough fuel to be obtained for cooking purposes.

J. F. PRICE,
Acting Collector, Chingleput District.

PALMANAIR, *June* 22, 1878.

Locusts have not, as yet, made their appearance in this district. The accounts which have been published and circulated by the board of revenue show very clearly that human efforts are powerless to cope with the calamity of a visitation of a swarm of locusts in the mature state when their locomotive powers are fully developed, and that it is to the destruction of the young swarms that our attention must be specially directed.

There is little doubt that when once the people are made thoroughly aware of the terrible loss that will be the result of apathy or indifference on their part, they will combine to kill the insects; this may best be effected—

1st. By bringing a number of plows together and as speedily as possible plowing up the lands where the old insects have alighted and deposited their eggs, while the women and children search the furrows and collect the bags of eggs, and for each basket so collected to pay a reward of 2 annas.

2d. After the young locusts have emerged from the ground the swarms of crawling insects to be swept into heaps and burnt with *straw*, brushwood, and rubbish placed upon them or else driven into deep trenches to be dug for the purpose, at the bottom of which fire may be kept burning, and they can thus be destroyed in large numbers. This latter will probably be found the most efficacious remedy; or they may be buried as the trench fills by the excavated soil that should be heaped on the further side from the swarm.

3d. By sweeping the young insects into sacks with wide mouths.

Much, of course, depends on the nature of the locality where the locusts are found, and the possibility of collecting people in sufficient numbers to exterminate them. In this district, where there are such extensive tracts covered with thick jungle, it will be difficult to get at the spots where the females deposit their eggs.

W. S. WHITESIDE,
Collector of North Arcot.

VEDARNILUR, *June* 15, 1878.

This district has hitherto been free from the scourge of locusts.

In regard to the question what step should be taken to rid the country of this plague, it is not easy to write with certainty; much will depend on the nature of the ground on which the insects first settle, and the direction of the wind.

It may in some instances be possible to light fires to windward of

them, and so destroy them either in the flames or smoke. The plan which may prove most effective will be to dig a trench and drive the locusts into it.—[From E. F. Webster, esq., collector of Tanjore.]

TUTICORIN, *June* 19, 1878.

The locusts which invaded Tuticorin have nearly all been driven by the strong west wind, not only to the "island" and Devil's Point (a tongue of land), but over these into the sea. They were all winged, and it would not have been possible to catch them. Fire was either impracticable or inadmissible. They appeared on 11th up to 18th, coming apparently from westward; but few are left at present behind the salt-pans where fire would be dangerous.—[From F. E. Gibson, esq., sub-collector of Tinnevelly.]

TRICHENDUR, *June* 21, 1878.

A very few locusts have been driven to the coast at Trichendur also.

J. B. PENNINGTON,
Collector.

MAY 30, 1878.

With reference to the reports I have lately sent to the Board regarding the depredations by young locusts, I have the honour to ask whether the Board contemplate sanctioning rewards for their destruction.

While holding that their extermination is a legitimate duty of the ryot, the people are so apathetic that perhaps as a special case it might be advisable to offer a small reward, say, 2 pies per measure, for all young locusts brought to the Taluq Cutcherry or produced before a revenue inspector. This would stimulate the small boys in a village to kill them in numbers, and once they get in the way of it the ryots would see that the undertaking was not so hopeless, as they now consider.

As to the offer of a reward for the destruction of eggs, I think it would be better to give rewards for the destruction of female locusts. Those that I have recently caught are gravid, and although there are comparatively few of them, and they are getting fewer every day, it would be a good plan to get those that there are destroyed. The female locust is easily distinguished from the male.

I would also suggest a reward of, say, 1 rupee for information as to fields or grass lands in which locust eggs have been deposited, leaving it to the village authorities to take measures for ploughing them up at once.—[From A. McC. Webster, esq., collector of Coimbatore.]

[From H. Tremenheere, esq., acting head assistant collector to A. McC. Webster, esq., collector of Coimbatore.]

PULLADUM, *May* 22, 1878.

In the twelve intermediate miles from Oodoomalpettah to Peryapatty very few traces of locusts were found. In one or two places where they were the ryots were in the fields driving them away. Their numbers did not appear to be unmanageable.

At Peryapatty they were in great numbers. The people had tried in every way to drive them off, but without success. I went to a cholum field where a fine crop was being destroyed, and as an experiment organized a drive. It was interesting as showing to what extent it is true that the ryots can do nothing to preserve their crops. This field was about a cawny in extent, and there were eleven beaters. Driving the insects (few only had wings fully developed) foot by foot down into

a corner, they there killed great numbers. Meantime, hardly any appreciable difference could be detected in the number of insects still left among the cholum; it was accordingly beaten again and a larger swarm driven out. The ryots filled two large cloths with locusts, which they burnt.

The field was not large, and the number of men engaged in getting rid of the insects was larger than most cultivators can employ. The result, however, in this instance, was not discouraging, for though there were many thousands of locusts left in the field, yet the crop was for the time saved.

You have been previously asked to sanction a small reward for each basketful of dead locusts brought in. If you should not think this advisable as a Government measure, I hope you will bring it before the relief committee. They will probably make grants to those whose crops have been destroyed; the wiser plan would be to try to prevent the destruction.

Stricter orders have been issued to the revenue inspectors to report about locusts. I fear that the real state of matters cannot be understood from the scanty information at present afforded.

The Board of Revenues have been addressed with reference to the offer of rewards for destruction of locusts.

A. McC. WEBSTER, Esq.,
Collector.

COIMBATORE, *June* 3, 1878.

APRIL 29, 1878.

[From J. H. Masters, collector of the Bellary district, April 6, 1878.]

Reports of large flights of locusts have been received from the western taluqs of this district. They appeared first about the 19th of March, but the direction they took is not given.

In the Hadagalli Taluq they appeared first in the Hollal, on the extreme western border, and took a northeasterly direction. This was about the 22d of March. They appeared at Kudlighi on the 3d instant from the south, and went in a northeasterly direction.

[Inclosure.]

[From J. G. Firth, esq., ex-deputy collector, Bellary division, April 3, 1878.]

At 8 a. m. this morning, hearing a great noise of people shouting in the direction of the town of Kudlighi, and learning from a Taluq peon that locusts had just began to attack the fields, I galloped down to the south of and close to the village where there are about 200 acres of paddy cultivation about half-grown, and saw a large flight of locusts about half a mile in width coming from the south. The villagers standing in the paddy fields, waving cloths and dried cocoanut branches, shouting, firing guns, and lighting fires, succeeded in a great measure in preventing the locusts from settling upon the paddy fields and upon the gardens of vegetables, &c., in their vicinity. But little damage was done to the crops. The locusts proceeded in a northerly direction, leaving few stragglers behind.

The locusts were of a reddish-brown color, varying in length $1\frac{1}{2}$ to $2\frac{1}{2}$ inches.

J. H. GARSTIN,
Additional Secretary to Government.

MAY 7, 1878.

[From Retired Surgeon-Major J. Shortt, M. D., to C. A. Galton, esq., acting secretary to the Board of Revenue, dated Yerkand, March 27, 1878.]

As locusts are said to be causing much destruction in the Tinnebelly district, I beg to make the following suggestions for their extermination: Locusts should be destroyed by employing men, women, and children, if available, to pick them off the infested plants, pull off their heads, and throw them into a basket for subsequent removal to a pit dug for the purpose, where in the course of time they will form excellent manure. A search must be made for their eggs in all the districts they have infested; these should be collected and burnt. A third exploration must be made for the young that may be hatched; these must be destroyed like the mature insect. When locusts have invaded a large field, a flock of sheep or goats, even cattle in large numbers, may be driven through them so as to trample them down and destroy them.

(A true copy and extract.)

C. A. GALTON,
Acting Secretary.

MADURA, *May* 25, 1878.

They (the locusts) went on increasing in size and number day by day and progressed rapidly towards the north and west till at last they spread over the whole division and destroyed all the flourishing crops before them, leaving nothing that could be of any use to the ryots behind, to the great disappointment and fear of the hopeful ryots. They do not seem to have disappeared from the district yet, but are met with here and there in small numbers, though not in swarms as before; and nothing is known of their ultimate destination or the length of their probable stay in the division, and all attempts hitherto made by the ryots to destroy them or check their ravages by throwing sand, ashes, &c., over them, or by beating drums, &c., with a view to drive them out, have proved futile, and no means, it is reported, can possibly be devised by them for their effectual destruction and annihilation.

SOORIAMOORTIA PILLAI,
Deputy Collector on General Duties.

MAY 23, 1878.

With reference to your telegram of the 22d instant, I beg respectfully to inform you that I proceeded to Pothanore as quickly as possible. The Monegar and three or four ryots were present, but did not know where the locusts were.

After some search in adjoining fields we came upon three swarms. They were all young and wingless, of the same size and color, showing that they must be of the same age and species; each group covered a small patch of ground, say about 15 by 10 yards. The ryots say these young insects must have immigrated from the south; that no large flights ever alighted on their fields, though they passed over them more than a month ago; and four or five days back they did not notice this pest.

I got about 40 men with sufficient material this morning, caused rolls of paddy straw and thirty torches to be prepared, got about 15 to 20 men to carry torches and sticks, and the others carried the straw and other materials.

We proceeded to one of the swarms. The rollsmen threw their straw rolls around an occupied tract and completely encircled it; the torchmen immediately set fire at different points, and when the insects moved toward the center, kept pushing the burning straw with sticks slowly behind them, killing many during the process. Some of the insects quickly escape whenever the parts of the burning material are extinguished.

The ryots granted that our method was successful, but they betray their shortsightedness, as they cannot see the necessity of working about insects in a field which does not belong to themselves.

MR. A. PINTO,
Acting Tahsildar of Coimbatore.

JELLIPATTY, *May* 19, 1878.

I regret to report that a very great portion of the taluq is infested with young locusts, whose ravages are very distressing. The southern half of the taluq appears to suffer most, and the further south we go they are more numerous. All the grass is eaten up and nearly all the garden crops. They must have bred on the Anamallays and found their way down, for the sides of the hills are covered with them, and, having eaten up all the pasturage, they may be seen marching deliberately down to the villages. They are also, so the forest overseer told me, eating the young bamboos.

Arrived at Dhully I rode out to the foot of the hills near Tiroomoorthypovil. Here the ground was literally covered with them. I collected about 100 people, and when I saw a large swarm I threw some straw over them and set fire to it. Some perished, but they were only a few out of the millions and millions there. In other cases I lit a fire half around them and got the people to drive them in.

In Dhully and in the village where I am at present encamped, they are even in the houses, and in some cases the people have been obliged to leave their houses. The destruction done by these locusts is enormous and distressing, when we consider that the cholum now being eaten is the third crop the poor ryots have attempted to grow. The cholum stalks are now calculated to feed the cattle for a year, but it is all gone; so what will the cattle do, as the grass is also eaten?

J. H. COOK, ESQ.,
Special Assistant in charge of State Relief Works.

RAWALPINDI DIVISION, PUNJAB, *July* 29, 1863.

The young locusts have begun to be hatched at Lahore itself, where there was previously no suspicion even of eggs having been laid, as also in the Gurdaspur district, in vast numbers. The old locusts have been laying their eggs at Sirsa, Hissar, Rohtak, Patiala, and other parts of the Sutlej, while they are stated to be laying them broadcast in Bikaner and other parts of Rajputana. In the Derajat and Peshawar divisions, as well as in Rawalpindi, and it is to be feared throughout the Salt Range and elsewhere in the north, the same process appears to be going on; so it appears certain the coming crops must be devastated far and wide—more especially the cotton crops, which have already begun to suffer—if the most resolute efforts be not made to destroy the eggs and young broods before they attain to maturity.

It is quite certain that the only stage at which these destroyers can be effectively contended with is while the eggs are still in the ground, or very shortly after the young have been hatched. The most effective mode of destroying the former appears, undoubtedly to be to plow up

the field repeatedly; while the young locusts while only a few days old may be destroyed with wonderful facility by driving them gently into a small ditch, previously dug for their reception, and then covered with earth well pressed down. When they are not above a week old a trench of 6 or 8 inches wide and deep, such as two men may form in a few minutes, suffices for securing the insects, which jump into it with alacrity, and appear wholly unable to extricate themselves from it.

J. A. E. MILLER, Esq.,
Financial Commissioner, Punjab.

LAHORE, *December* 10, 1869.

Assuming that there are two approved methods of destroying these insects, viz., by digging up their eggs, and by driving the young brood into shallow trenches dug across their course, it appears to the officiating financial commissioner that the villagers in the Punjab are as much interested in performing these operations as they would be in endeavoring to extinguish a conflagration which threatened the destruction of their houses; and that as a rule no remuneration should be thought of, although the collection of the people must be effected by the exhibition of authority.

In the locust visitation of 1863 it is believed that considerable sums were defrayed in payment for eggs, which were in several districts bought by weight and destroyed; but even in that year the labors of the population generally were not remunerated, nor was any remuneration expected.

During the present year, when locusts have been seen in large numbers, and have also laid their eggs in several districts, no application for any payment whatever has been made to this office, although it was intimated that funds would be provided if necessary, and it is believed that, with one exception, which has come incidentally to notice, there will be no application made.

There no doubt may be circumstances under which payment would be necessary, as, for instance, when the *locale* of the locusts or their eggs is far distant from any village, and the people have to be collected with great inconvenience to themselves.

J. A. E. MILLER,
Secretary to Financial Commission, Punjab.

LAHORE, *January* 27, 1870.

I am desired to acknowledge receipt of your letter of the 10th of December, communicating the views of the financial commissioner in regard to expenditures incurred in the destruction of locusts; and to state that the honorable the lieutenant-governor concurs generally in these views. Where the people themselves are engaged in the work of destruction in their own villages, it is certain that no outlay should be ordinarily incurred; but exceptional cases may occur where some outlay will be necessary, and amongst them are cases such as referred to in your letter, where eggs have been laid at a distance from the villages, and then possibly some outlay would have to be incurred, which would, in the lieutenant-governor's opinion, be fairly chargeable to the adjoining villages that would be the first to suffer if the young locusts remained undestroyed.

I am also to observe that the destruction of the eggs should, in His Honor's opinion, be, as a rule, discouraged. It is a difficult operation

and by no means certainly successful, and the destruction of the young when first hatched is an exceedingly simple operation, and certain and effectual in its results.

T. H. THORNTON, Esq.,
Secretary to Government.

DHIMBUM, *June* 21, 1878.

In reply to your memorandum dated 14th instant, I have the honor to inform you that all monegars have been directed to send immediate reports of the appearance of locusts in their villages.

I have personally destroyed three separate swarms of locusts on these hills, and, from all I can hear, this is evidently a regular breeding ground. Of course some escaped, but I believe I am not exaggerating when I say I destroyed millions.

I lighted fires about a yard wide in a semicircular form for about 100 yards, and then with the aid of coolies drove the young locusts into the fire; those that attempted to return were killed by the coolies, who were armed with branches of trees. In two places I found them so numerous that I set fire to the grass, as the only means of destroying them. So great were the numbers that the smell arising from the burnt insects was positively offensive, and I believe that the comparatively few that escaped were mostly too much hurt to live.

Nothing will induce the young insects to separate, and I found I could have a succession of "drives," as by giving them an hour's rest those that escaped invariably collected together again; so I was enabled to continue their destruction from 8 a. m. to 5 p. m.

A. C. McGREGOR,
Deputy Collector Northern Division of Coimbatore.

MUDIVED, *July* 9, 1878.

I have to report the appearance of locusts in this district. One swarm was first noticed by the sub-collector yesterday evening at Kandlamadugu, and I noticed the same swarm passing to the eastward as I rode here this morning. The villagers here tell me that another swarm left this village yesterday morning and flew away to the east, but apparently taking a more northerly direction than the swarm I saw this morning. In this village no eggs have been found as yet. Ten acres of very young sazza were destroyed in this village, and the leaves of sugar-cane were also eaten, but the crops will survive.

The villagers of Kandlamadugu drove the locusts from their fields, and this I believe to be quite possible from the manner in which my horse disturbed some locusts this morning.

Some ten persons trailed branches over the sugar-cane, and this failed to remove the locusts. If ryots would combine, they could, with the aid of cattle, drive locusts from a dry crop and save it, if this be done immediately a swarm alight.

The locusts came from the westward, and most probably from the Mysore country, where I believe the swarms are very numerous.

W. D. HORSELY, Esq.,
Collector of Cuddapah.

APPENDIX IX.

EXPERIENCE WITH THE SPRING CANKER-WORM.

By MARTIN A. HOWELL, JR., of *Greenwood, Henry County, Illinois.*

DEAR SIR: I take pleasure in submitting to you the details, in substance, of the means employed to save my apple crop during the year last past, which was threatened with complete extermination by clouds of canker worms, which have become a scourge to the orchards of a large portion of this part of the State. Having purchased this farm but the year previous, being unaware of their presence in such numbers, and preoccupied with other duties, I found no time to devote to them such attention as the necessities of the case demanded at the late hour their discovery was made known to me.

As a means, however, of reducing the labor of the following season of work I procured a competent person to trim the trees of their excessive central shoots and branches, in order to open up the interior and enable us to reach more effectively our object. (This was done in June.) In the interim the soil for some 12 feet distant from the trunk was loosened up, a copious dressing of liquid manure turned in, and the surface top dressed with good dry compost in order to give all possible vigor to the trees to enable them to withstand the shock of the loss of foliage and pruning of the present season.

The following winter of 1877–'78, it will be remembered, was one of unusual mildness, the spring opening early, the weather unusually fair, and the soil in condition very favorable to insect life.

During the warm, showery weather of March, when the bark was soft and friable, I scraped the bark of the trunks and larger branches, after which they were washed with a preparation of lime and sulphur thickened to the consistency of paste, with good *alkaline* soft soap, which afforded considerable amusement to the farmers as they passed by, and was reckoned a waste of time and money to no purpose.

A casual examination of the trees revealed the presence of other enemies which had been left comparatively undisturbed for some years prior to my occupation. Among these I will mention the leaf-crumplers in abundance, and the scale, which, in conjunction with the canker worm, were making the life of the orchard a brief one. A careful examination of some of the nests of the leaf-crumplers brought to light a goodly store of eggs, which aroused my suspicion at once; these were placed under a glass and hatched out in the sun in a few days, every egg producing a canker worm. I called the attention of several of my neighbors to the matter, and advised prompt and decisive measures to destroy them early in life. No action was taken by them at the time named, and in every case the foliage and crop were entirely destroyed. These new-fangled notions of theoretical farmers were looked upon with much suspicion, and the plucking of the nests of these leaf-crumplers was postponed *sine die.*

With the bursting of the leaf buds came swarms of canker worms,

preying at once upon the tender leaves. Prior to active operations, and before the increase of foliage rendered the task more difficult, we wiped out every nest of the tent caterpillar, which began to appear in the forks of the branches, then in the tender condition of early existence.

I then took my garden engine, one procured for this specific purpose, with 25 feet of rubber-hose, nozzle and fine rose sprinkler, built a temporary sled of boards to carry three or four barrels of soft water, and with four pounds of *pure* arsenite of copper, a barrel of soft soap, and a team to draw the sled from tree to tree, we commenced our foray on these pests of civilization before the foliage could afford a screen to the searching spray of the sprinkler. About two pailsful of soap was placed in each barrel of water and thoroughly dissolved. A fine No. 80 sieve was placed over the tank of the garden engine, which was filled with the liquid, great care being taken that no dirt or foreign substance passed through, in order to give a free and unobstructed discharge to the minutely perforated sprinkler. About two tablespoonfuls of pure arsenite of copper was then thrown in the tank and kept well agitated, when my assistant mounted the tree, directing his attention to the washing of the upper part of the tree, and the lowermost after descending, every part being thoroughly washed.

Heavy showers and storms of wind interrupted operations frequently, and where any worms escaped destruction they would take advantage of the opportunity, drop down on their thread, and swing off with the wind to adjacent trees; and pass from tree to tree until they reached that part of the orchard yet untouched by the wash, until every tree so treated was thoroughly cleansed of the worms. These, however, were slowly driven west as the work advanced from the opposite direction, the wind blowing during the time from the east quite heavily; many, as they swung off on their threads, being carried across the road into the adjoining fields by the force of the wind. An interruption, followed by a change of wind to the west, carried many back; which necessitated another washing; some trees being syringed three and four times. In many cases the more mature worms will drop on their thread, and remain suspended in mid air for a long time, and are easily gathered upon a rod swept quietly along through their webs, drawn through the hand, and destroyed. Our orchard being in two parts, the new and the old, our first attention was given to the former, as the trees were large and laden with blossoms. Here the work was effectual; not a worm left of the millions; and I can truly say that there were enough worms upon any *one tree* to consume the foliage of the entire orchard had they been left to mature, as the brown-and-crisp-appearing orchards for miles around bore ample evidence.

The work completed, the trees burst into an apparently new life, much of the scale being destroyed by the later washings, and the resulting heavy crop amply repaid us for our labor and trouble.

Of the trees in the old orchard, which received attention later in the season, and upon which there was a comparatively poor promise of fruit or future existence, many of the worms had attained sufficient size to enable them to escape the searching agent by swinging off and reaching the ground.

Here we made other tests in order to check their return to the trees. We cleared away the surface for about twelve inches around the collar of each tree, pressed the earth down smoothly and compactly, and placed thereon a belt of powdered sulphur. We then coated a portion of the bark with a plastic solution of boiled linseed oil and rosin. Above this a belt of soft soap and sulphur, each encircling the tree about 8 inches

in breadth. The wonderful persistence and determination of this worm was soon manifest, for while many were killed by us in their attempts to storm the works, many succeeded during the night in wallowing through every obstacle, and again succeeded in reaching the branches.

We are, therefore, of the opinion that for practical effect the work must be done when the worms are just hatched out, while they are in their age of tender existence, and as they begin to prey upon the bursting foliage of early spring. Here we have every worm at our mercy, and armed with the proper writ they will not be slow in their obedience to the unpalatable summons.

While we write the above report, March 16, we beg leave to introduce the additional means made use of to prevent the ravages of these pests by preventing the ascent of the female insect to the trees, where she deposits her eggs.

The winter, it will be remembered, was marked by an unusual snowfall, and one of more than ordinary severity; and from about the 1st of December, 1878, to March 10, the ground was covered. The sudden approach of warm weather carried off the snow rapidly, and called us to action. The drying southwest winds soon brought to life those which had escaped into the earth the previous June; but we were prepared to meet them. Our trees were carefully scraped about three feet above the collar, and a tenacious and plastic coating of treacle and boiled oil, with some rosin, mixed and heated so as to make all homogeneous, was then brushed on, forming a belt about twelve inches. This we watched carefully, and as the ground became drier the numbers increased; the large preponderance being males, which perished at once on being hopelessly fixed; while the females, all heavily laden with eggs, succeeded in wallowing a few inches, where they were found firmly adhered in the morning, and killed.

The prevailing strong southwesters and westerly winds, with the sudden changes in temperature from 70° to 22° below the freezing point, wrought such changes in the surface of our plastic composition as to require frequent additions on the windward side of the trees, glazing them over during the day to such an extent that many, without doubt, passed over during the night in the old orchard; while in the new but few were seen at all, and these all secured. The degree of cold which these insects can endure is rather surprising when we consider the sensitiveness of insect life to the changes of temperature. After each of our warm days, when the mercury marked 60° to 70°, frost and some ice followed; and though no apparent movement had been made by the insects up to 8.30 p. m., with the mercury at 40°, a complete cordon of males was found in the morning adhering to the bands, and what few females had ventured out. On the succeeding day we noticed the wind veering to the northwest, blowing a gale, and at 6 p. m. again recoated the trees; mercury, at 7 p. m., 45°, falling to 10° at 6 a. m. On examination we found many insects as before, twenty males to one female; and to test the tenacity of life of the latter, we suffered many to remain during two days of cold freezing weather, with the mercury varying from 10° to 20° in the sun, wind strong, northwest, and exposed; ground again frozen, and covered with a light fall of snow. After the second day's exposure, with the mercury at 10°, we carefully gathered them in, exposed them to the warm rays of the sun in a room; when immediate signs of life were shown. All came through the ordeal uninjured, and in their attempts to crawl off were placed between pieces of glass for microscopic observation. The pressure of the glass caused large numbers of eggs to exude, every one

of which could be seen readily with an ordinary lens. The eggs appear to consist of two colors, dark and light, the light predominating in the proportion in which we find the males predominating in the perfect insect; this, evidently, accounting for the variations in the color of the worms while preying on the foliage. Of these specimens I have preserved a number as above prepared for future reference.

Considering, therefore, the severe climatic changes in this region, together with the long continued gales of drying winds from the west and southwest during the early spring months, which calls forth every exertion to keep the plastic bands in proper condition, the tenacity and persistence of these insects, and their endurance of the extreme changes of temperature, the liability of the adhesive coatings to become bridged over by floating matter carried along by the winds, we cannot fail to conclude that the most practical means of relief lies in the destruction of the grub early in spring after hatching out, and that the work should be prompt to be effective.

Permit me to call attention to the use of pure arsenite of copper, as imperative to success. I use the term arsenite of copper in preference, from the fact that long experience in the use of this poison in manufacturing in the East enables me to assert that the ordinary Paris green sold in our drug stores for agricultural purposes is largely composed of sulphate of baryta, the specific gravity of which misleads those unaccustomed to its use, and is therefore not arsenite of copper, but an adulteration—the greatly increased demand for which, since the advent of the Colorado beetle, by the agriculturist, increased the incentive to adulteration by unscrupulous German Jews, who are the principal manipulators in this country. Upon this may be laid the causes of failure of many to accomplish the desired end, though particular to follow the details of practice.

Again, the use of a good force pump is requisite. There are many such pumps to be procured with air chambers mounted on wheels with the capacity of a barrel, which with some twenty-five feet of hose-pipe, nozzle, and sprinkler cost about $15. A number of our neighbors have procured them since our trials, and where one found the burden of expense too great, two or more clubbed together in the purchase.

It is the general opinion, if I mistake not, that the canker worm is local, in consequence of the fact that the female is wingless, and therefore cannot spread. This I find is an error, more particularly in this locality so lavishly favored with high winds. Caught up by the gales, while suspended upon their gossamer web, I have seen multitudes carried far away, flying thus supported for long distances, reminding one of the gossamer spiders which float along on a moderate breeze; using the same means of transit comparatively. That they have spread over a large portion of the Northwest within a few years the blackened and seared foliage of our orchards tell—a fearful truth. And it is the settled conviction of all our orchardists and farmers that unless the proper means are used to destroy these pests, and before much time has passed away, that a crop of apples will be a thing of the past, and our orchards will give place to more remunerative purposes. At the present rate of destruction by the canker worm and scale there is but a step from the living to the dead.

Prof. C. V. Riley.

INDEX.

CORRIGENDA.

Page 241, lines 30 and 31, for Lears, read Sears.
Page 253, line 13, for lower, read basal.
Page 253, line 34, for Pl. VI, read Pl. VII.
Page 253, line 36, for long, read broad.
Page 254, line 18, omit "and No. 4, p. 241, on the hemlock."
Page 254, line 2 from bottom, for Maxillæ, read Maxillary palpi.
Page 257, line 10, for long, read broad.
Page 257, line 5 from bottom, after segment, insert above.
Page 258, line 2 from bottom, for shorter, read longer; and for wider, read narrower.
Page 259, line 20, for round, read broad.
Page 259, line 29, for segment, read segments.
Page 269, line 25, for Fig. 3, read Pl. LXIII, fig. 4.
Page 269, last line, for Gengenbaur's, read Gegenbaur's.
Page 271, line 4 from bottom, after complete, insert as.
Page 287, line 1, for fundamenta, read fundamental.
Page 291, line 14, after the, omit the.
Page 291, line 19, for lobes are, read lobe is.
Page 293, line 13 from bottom, for Corydalis, read Corydalus.
Page 293, line 11 from bottom, for fig. 5, read fig. 2.
Page 294, table, line 9 of last column, for Physapoda, read Physopoda.
Page 294, line 4 from bottom, for Physapoda, read Physopoda.
Page 296, line 19 from bottom, for urites, read urosternites.
Page 297, line 2, for Physapoda, read Physopoda.
Page 300, line 8 from bottom, for 3 ocelli, read 2–3 ocelli.
Page 300, line 6 from bottom, for often present, read rarely absent.
Page 301, line 21, after any, read carnivorous forms.
Page 303, line 3 from bottom, for Betra htungen, read Betrachtungen.
Page 304, line 3, for [150], read [150a].
Page 304, last line, for [150], read [150a].
Page 306, line 7 from bottom, for met-episternum, read met-epimerum.
Page 307, line 3, for Figs. 10–12, read Pl. XXIII, figs. 10–12.
Page 308, line 9 from bottom, omit (Pl. XXIV).
Page 322, line 5 from bottom, for CORRODENTIA read PLATYPTERA.
Page 322, line 4 from bottom, after Plates insert XXXIX.
Page 322, line 2 from bottom, before Pl. XL, insert Pl. XXXIX, fig. 8.
Page 324, line 8, for sub-epimerite, read sur-epimerite.
Page 325, line 3, for Plate, read Plates.
Page 325, line 5, for figs. 6–8, read figs. 6, 7.
Page 325, line 15, for heade, bing, read head, being.
Page 326, line 10, for figs. 3, 4, 8, read figs. 3, 4, 8, 9.
Page 327, line 23, for Fig. 4, read Pl. XLIII, fig. 4.
Page 327, line 8 from bottom, for Fig. 4, read Pl. XLII, fig. 4.
Page 328, line 8, for Fig. 7, read Pl. XLIII, figs. 7–9.
Page 328, line 13, for Figs. 7–9, read Pl. XLII, figs. 7–9.
Page 328, line 18, for coxæ, read trochantines.
Page 330, line 5 from bottom, after *pronotum*, insert (Pl. XLVIII, fig. 2).
Page 330, last line, after fig. 8, insert Pl. LXIII, fig. 4.
Page 331, line 5, omit (Fig. 3, v. 5.).
Page 331, line 16, omit (v. 5).
Page 332, lines 22, 32, and 33, for trochantine, read coxa.
Page 332, lines 24 and 33, for coxa, read trochantine.
Page 333, line 22, for *E. cupida* (Leptophlebia), read *E.* (*Leptophlebia*) *cupida*.
Page 334, line 9 from bottom, for *epis''*, read *epis'*.
Page 336, line 8, for gulæ, read genæ.
Page 336, line 11 and last line, for [154], read [154a].
Page 336, line 27, for Fig. 12, read Pl. LXIV, fig. 7.
Page 336, below figure, insert Fig. 14.—
Page 336, line 39, after (Corydalus)., insert (Pl. LXIV, fig. 8.)
Page 337, line 10, after as large, insert in proportion.
Page 337, line 15, for Fig. 2, read Pl. LXIV, fig. 2.
Page 337, line 16, for supra-sternite, read supra-episternite.
Page 337, lines 19 and 20, for short, read large; and omit the words, The trochantine is very small; one-half as large as the coxa.
Page 337, line 25, for Fig. 12, read Pl. LXIV, fig. 3.
Page 337, line 28, for undivided, read divided.
Page 337, lines 29 and 30, omit the words, The trochantine is a little smaller than in the mesothorax.
Page 337, line 7 from bottom, for Fig. 4, read Pl. LXIV, fig. 4.
Page 339, line 22, for Pl. LVII, fig. 8, read Pl. LVI, figs. 8, 13.
Page 340, line 9 from bottom, after *Mantispa*., insert (Pl. LV, fig. 7.).
Page 340, line 3 from bottom, for suprasternite, read supra-episternite.
Page 341, line 13 from bottom, after *Mantispa*., insert (Pl. LV, fig. 9.).
Page 342, line 1, after *mesosternum*, insert (Pl. LVI, fig. 11.).
Page 342, line 3, after meta-, insert (Fig. 12.).
Page 342, line 6, after *mesosternum*, insert (Pl. LV, fig. 5.).
Page 342, line 8, after metasternum, insert (Fig. 6.).
Page 342, line 17, for 7th, read 8th.
Page 342, line 20, for Plate LX, read Plates LIX, figs. 6–10; LX.
Page 343, line 5, for fig. 15, read fig. 5.

Page 343, line 18, for fig. 9, read fig. 8.
Page 343, line 22, for fig. 8, read fig. 9.
Page 343, below figure, insert Fig. 15.—
Page 344, line 3, for Fig. , read Fig. 15.
Page 344, line 15, for Fig. —, read Fig. 1.
Page 344, line 20, for Fig. 5, read Fig. 4.
Page 344, line 23, for 5, read 2.
Page 344, line 3 from bottom, for *Prhyganea* read *Phryganea.*
Page 345, line 13, for is not subdivided, read is divided.
Page 345, line 16, for coxæ, read trochantines.
Page 345, line 16–17, for trochantine, read coxa.
Page 345, line 17, for coxa, read trochantine.
Page 345, line 20, for coxæ, read trochantines.
Page 345, line 21, for trochantine read coxa.
Page 345, line 14 from bottom, for urites, read urosternites.
Page 345, line 3 from bottom, omit the * after Brauer.
Page 346, line 11, for cricket read crickets.
Page 346, line 8 from bottom, for Orthoptenus read Orthopterous.
Page 347, folio line, for BLUESTONE, read GEOGRAPHICAL DISTRIBUTION OF ROCKY MOUNTAIN LOCUST.
Page 347, line 5, for Myripods read Myriopods.